Attachment 4

IChemE President's Address – April 2004

EXECUTIVE SUMMARY

Sustainability is the catch-cry for the new century. It is strongly suggested that the future of engineering lies within enhancing sustainability as its importance grows to the global community. Chemical engineers are beginning to approach their work in new ways but more changes are needed. It is not the sole responsibility of engineers to 'fix' current problems. Rather it must be a united front between scientists, businesses and society to implement new methods and technology that eliminates unsustainable practices.

The future of sustainability includes raising expectations and recognising the pace of change and globalisation. It is a concept that integrates economic activity, environmental integrity, social concern and effective governance systems. This integration is achieved through setting long-term and short-term objectives.

The three essential components of sustainability are social, economic and environmental factors – the triple-bottom line. Many also add a fourth dimension and consider business-ethics. It has been demonstrated that improvements in one element comes at the expense of the other elements.

The accepted Bruntland definition for sustainability states that it is the 'advance of human prosperity in a way that does not compromise the potential prosperity and quality of life and future generations'. Behind this definition prosperity advancement can be taken for granted. Sustainable development can only be realistically accomplished if approached in a multidisciplinary way.

Chemical engineers take relevant information, incorporate it with best practice, yielding a process and product that takes into account life cycle analysis and satisfies the needs of the community. They try to find a preferred pathway through uncertainty but cannot justify their failures by highlighting their successes. Process system engineers are best positioned to further sustainability as they adopt a holistic or systems view which is essential for modelling complex interactions between industries, society and ecosystems. They modify designs and operations of existing process to increase sustainability and have the opportunity to broaden the 'chemical supple chain' into the 'chemical value chain'.

The interests of chemical engineers and the purpose of sustainability lie in considering outcomes and implications. Sustainability is a strategic framework, which builds on traditional engineering frameworks of mass and energy balances. The challenge facing the engineering profession is that when developing scenarios it can lead to contradictory paths. In addition there is the lack of understanding of sustainability at an undergraduate level and gaps in the way it is currently incorporated into course work.

The general perception is that sustainability is the future for chemical engineers where they will begin to provide options over problem solving. Chemical engineers are in a unique position to generate options and promote sustainability, as the nature of the discipline is reductionist, deductive and deterministic. However alternatives suggest that sustainability requires a united global front prior intervention by chemical engineers. This idea is closely linked with the need for absolute definitions and standards. Ultimately those who do not believe it is the future of chemical engineers question whether engineers will just accept that some processes are unsustainable.

Organisations choose to adopt sustainable practices for the enhanced reputation, competitive advantage, cost savings and emphasis on corporate ethics and accountability. This means it adheres to the triple bottom line.

As a result of the diverse nature of industries it is impossible to adopt a one-size-fits-all approach to frameworks and measurements of sustainability. Once a business decides to adopt sustainable development, the company must reconsider its existing strategies.

Businesses can choose to adopt value creation frameworks where the underpinning idea is that sustainability is achieved more rapidly if profit motive is the dominant driver and framework for analysis rather than corporate social ethics. Here if value is at stake in sustainability, successful strategies to manage sustainability will create value. Other alternatives for businesses include design for sustainability, eco efficient manufacturing, industrial ecology and implementation of Process System Engineering methods. Then a practical tool and specific action in the pursuit of sustainability is reporting, again a number of formats can be utilised but organisations must ensure they do not fall into the trap of viewing reporting as a sustainability strategy rather than a tool.

Simple and effective approaches, which are also being adopted, include a sustainability scorecard and conventional sustainability performance indicators. A possible follow on from these could be using the public's perceptions of the industry in models and charts.

Ultimately businesses must create robust frameworks based on an agreed set of broad principles. However, despite heightened awareness and commitment to sustainability, many companies find it difficult to transfer goals into day-to-day decision-making.

An industry example can be used to demonstrate changes in approaches to sustainability. Here the mining industry is trying to replace images of social destabilisation and environmental destruction. The key question is whether or not mining can be made truly sustainable. The use of the Mining, minerals and Sustainable Development Report is a way for the industry to direct the future towards a number of key areas, which promote sustainability in very practical ways.

Actions taken to support sustainable development include widespread understanding, organisational-level policies, collaboration and working on a local, national and global level. The Australian Government acknowledges that it must actively assist in the country enhancing its sustainable practices where national research will focus on emissions reduction, wastewater disposal and recycling. It is ensuring that there is a rise in multi-disciplinary research as sustainability is an issue crossing many fields of expertise.

The question remains as to how one measures the successful implementation of sustainability. This idea will become increasingly important to reaching sustainability and the solution could possibly be the formation of a Sustainable Development Support Facility.

Another key point is that sustainability cannot be achieved without stability between economic, environmental and social factors. Exploration of this field could lead to new discoveries and the creation of models demonstrating the rate of change tolerated by each of the triple-bottom line determinants to assume an overall sustainable and successful position.

Organisations such as IChemE, has a role in shifting perceptions. The creation of an internal research group which focuses on sustainability at a community, industry and tertiary education level is a way to provide support for professionals and ensure that new engineers are actively enhancing sustainability.

SUSTAINABILITY

Life is dependent on the productivity of ecological systems like the atmosphere and the oceans, croplands, forestlands, freshwaters. Degrade the productivity of those systems by over exploitation or pollution and the productivity of the global economy is reduced. Unfortunately little headway has been made with environmental problems such as climate change and loss of biodiversity. Such progress as has been achieved has been largely due to three factors: more decision-making at local level, technology innovation and the rise of market forces in environmental matters.

Since the 1970's there has been an increasing corporate response on environmental matters. There has been a shift from environmental matters being issues important only to minority groups through to a series of attitudinal changes by management. The catch-cry for the new century is 'sustainability'. Its ideal is all encompassing of the way humans interact with the environment. It is a logical extension of current community concerns – looking after the planet and still maintaining a comfortable lifestyle. The future of sustainability includes raising expectations and recognising the pace of change and globalisation. It requires integrating economic activity with environmental integrity, social concerns and effective governance systems. The approach taken to achieve this integration has to be comprehensive and forward-looking, setting out long-term and short-term objectives.

Sustainability is a concept that incorporates economic, environmental and social factors. These are the three essential components of sustainability (also known as people, plant and profits). Many also add a fourth dimension and consider business ethics. These elements are essential and interdependent. It has been demonstrated that improvements in one element comes at the expense of the other elements. For example, environmental performance can be improved but often at the expense of economic performance. There is a limit to how fast society can change; how fast financial vehicles and investments can move or how fast biodiverse systems can respond to environmental changes without significant loss. Some stability in the community is required as a necessary condition to engage economic and environmental performance. Sustainable assets covers all stocks ('capital') that are exchangeable between us, internal to ourselves and external to ourselves whilst adhering to the triple bottom line.

The idea of 'capital' lies at the heart of sustainable development. It goes well beyond the common idea of financial capital and has five main forms: natural capital; manufactured capital; human capital; social capital; and financial capital. A way to understand the relationship of 'capital' to sustainable development is to divide decisions into three groups of 'win-win' decisions, 'trade-off' decisions and 'no-go' decisions. Many of the complicated decisions that need to be made on the path to sustainability will involve compromises or trade-offs: between different objectives and dimensions, between different groups of stakeholders, between different generations.

Companies wishing to pursue a sustainable system design have a strong motivation to consider the broad implication of an innovation with all its stakeholders alluding to the notion of economic, environmental and social and the triple bottom line. Employees expect the system to be safe and operable. Shareholders expect changes to streamline existing operations and provide improved return. Customers expect efficiency and convenience. Public interest organisations expect environmental and social benefits.

The widely accepted Bruntland definition for sustainable development means the advance of human prosperity in a way that does not compromise the potential prosperity and quality of life of future generations. Behind this definition, prosperity advancement can be taken for granted. It is recognised however that this advancement must be managed to occur within particular constraints. If it were to be achieved in the manner of those who are already prosperous, the overwhelming evidence is that it could be short-lived. There are three other ideas to be linked with the fundamentals of this definition and they are: that poverty is a major threat to sustainability; time scale is of importance due to the unavoidable time required for land to rejuvenate; once particular resources are exhausted with no new stocks found, alternatives must be discovered.

Based on this Bruntland definition, sustainable development can only be accomplished if it is approached in a multidisciplinary way. The reductionist practice of scientific research tends to focus on the details of the system, unaware of the broader implications of the work. It is a narrow view that is enhanced by difficulties crossing disciplinary boundaries. Environmental issues affect so many disciplines and therefore the notion of a multidisciplinary way is essential.

The total available set of technology has a key function in sustainability: it delivers the goods and services to society in order to fulfil the needs of the population. The inputs of these technologies are resources withdrawn from the environment and waste products from society. From this technology perspective the major aspects of sustainability are efficient resource intake and conversion and reduction of emissions.
A focal question in sustainability discussions is 'can resources be used to meet today's needs without irreparably harming the needs of future generations?' The central thought is that society needs to build, not deplete, its stocks of capital, whether economic, natural or human. However, without dramatic changes in the patterns of human activity, there will be severe challenges to the continued growth of global industries with adverse environmental and socio-economic impacts.

Sustainable development means protecting the ability of future generations to attend to their own needs. 'Sustainability' is a postindustrial construct, originally developed and highly valued by postindustrial societies. If this means there will be a sustainable postindustrial age, its qualities should include:

Post Modern	**Sustainable Post Industrial**
No objective of realities	'Knowledge/Information' is key
Individualistic/ self centred 'Deconstruction'	Individual knowledge valued, Collective responsibility
Anarchy	Networks/Interdependence
Chance	Pathfinding
Science/technology as 'evil'	Science/technology 'harnessed'

The concerns that led to the global thrust towards sustainable development resulted from the realisation that materials consumption (including metals) would continue to grow with increasing needs and human population. The long-term effects of stabilised materials intensity, stable global population and high recycling rates will ultimately result in reduced demand for primary materials. However, this stabilisation will not occur until materialisation of developing countries is complete, and materials substitution trends are exhausted. This focus on sustainability also provides, with newfound urgency, the need to develop technologies that produce primary metals more effectively than those in the existing mining, processing and smelting value chains.

Responding to the challenges of sustainability requires insight into the characteristic of a sustainable system and a fundamental rethinking of how all industrial products and processes are designed, built, operated and evaluated. A sustainable product is therefore one that constrains resource consumption and waste generation to an acceptable level, makes a positive contribution to the satisfaction of human needs, and provides enduring economic value to the business. It is the determination of an 'acceptable level' that represents a major technical challenge. Sustainability requires boundaries of 'the process' to be greatly expanded – beyond the plant and corporation.

An interesting perspective is that sustainability is not an end state that can be reached; rather, it is a characteristic of a dynamic, evolving system. This means products or services cannot be sustainable in an absolute sense; rather, it must be considered in the context of the supply chain, the market and the natural environment. Ultimately individual products or enterprises cannot be deemed sustainable in isolation.

In the industrial age, chemical engineering has avoided the main dangers of being too specialised. Chemical engineers know how to take relevant information, incorporate it with best practice – having due regard to economics, safety and the environment – to yield both a process and a product that takes account of life cycle analysis and satisfies the needs of the community.

Among all specialities of chemical engineering, process systems engineering (PSE) is considered best positioned to address the challenges of sustainability. PSE adopts a holistic or systems view, essential for understanding and modelling the complex interactions between industry, society and ecosystems. It can play a critical role in modifying the design and operation of existing processes to make them more sustainable, and in developing new products and technologies that are inherently designed for sustainability. It has the opportunity to broaden the 'chemical supply chain' to the 'chemical value chain'. As a result of incomplete understanding of natural, economic and social systems, a theory of sustainable systems presents a multidisciplinary challenge where PSE may be able to develop theories by combining its expertise in large non-linear dynamic and complex systems into ecosystems.

Following on from the 1992 Rio de Janeiro environmental summit, there was an almost universal endorsement of the drive to sustainable development. It is useful to look at the progress towards sustainability after an event such as Rio and the Earth Summit in 1993. Sustainability recognises the advance of human prosperity in a way that does not compromise the potential prosperity and quality of life of future generations. The value of the test of sustainability is not so much in what it stops us from doing, but in what it encourages us to do differently. No longer will it be acceptable for the lack of full scientific certainty to be used as a reason for postponing cost-effective measures to prevent environmental degradation.

The level of concerning emanating from Rio for the sustainability of development activities has had the following impacts:

- Growth of 'social' funds that selectively invest in successful corporations based on social and environmental criteria
- Expectations of some shareholders that corporations and funds managers will work to ensure improved environmental performance

- Expectations of some voters that governments will meet commitments made to sustainable development, and properly control the activities of corporations
- Government support for corporate activities that therefore depends on binding commitments to certain programmes
- Alliances between business groups and global interest organisations of governments aimed at emergent outcomes that meet the needs of all parties.

One implication for chemical engineering is that the dominant proportion of the growth in industrial activity is in Asia and South America, where industrialisation is occurring most rapidly, and is highly valued as a source of economic advancement. Chemical engineering as a profession has been a child of the industrial age.

The nature of chemical engineering is in using basic scientific principles to solve practical problems. In the work of chemical engineers it is vital to always consider the outcomes and implications. Sustainability is all about this, and therefore makes a good framework for our interactions with the community. As a strategic framework for chemical engineering, sustainability builds nicely upon the traditional framework of mass and energy balances. At the most practical level, it offers concepts easily grasped by the classically trained chemical engineer. Also, sustainability and its key elements such as life cycle analysis, require teamwork and a multi-disciplined approach. Strong interaction with all stakeholders is necessary, making it a good framework for community interaction. Before considering or adopting a new framework, it is necessary to understand the current modes of interaction between the chemical engineering profession and the community. These interactions occur on levels such as community interaction and the licence to operate; forced (regulatory) interactions and voluntary interactions (where overlaps occur between forced and voluntary). As a part of these interactions, chemical engineers have a duty of responsible care. Regardless of the dimensions of regulation and self-regulation (i.e. forced or voluntary), interdependence of chemical engineers with the wider community must be acknowledged. That interdependence is not power-based but rather one that attempts to satisfy mutual needs.

Issues of sustainability that fall within the control of chemical engineers can be found in proposed frameworks and the core elements fit well with elements that are the essence of chemical engineering – mass and energy balances, rate processes and HAZOP analysis. Other important factors include a focus on risk analysis; indicators for effects on the community; and guidelines for informing and educating stakeholders. The frameworks can be implemented by adoption into chemical engineering curriculum; inclusion in further education and training programs; and guidelines stipulated by the societies and linked to certification. But for any framework, for community interaction to succeed it must incorporate three key elements of trust: stick to the facts, state intentions clearly and be consistent.

Sustainability is a framework that is being embraced; it links and accommodates the concerns of the community and society's direction in the 21st century. However for chemical engineers, sustainability is not just about integrating environmental consideration with the bottom line, it is about making best environmental practice, product stewardship, partnership and transparency integral to the bottom line. It is also about people's expectations and aspirations, the framework in which they operate and their understanding of risks and rewards. In a changing society, a proactive position is required – preventing the chemical engineering profession being caught by extreme swings. The chemical engineering industry has the will to contribute positively towards sustainable development – but it cannot do it alone.

Engineers are in the business of finding preferred pathways through uncertainty. They use their skills to improve the quality of life: foster employment, advance economic and social development and protect the environment. This challenge (improving the world for future generations) encompasses the essence of sustainable development. However, engineers cannot expect to justify failures by highlighting successes. Even relatively rare and temporary environmental emissions that affect local communities will quickly override other sustainability impacts, particularly when they are less observable. For example, at the local level things like fallout, noise and odour can be more damaging to perceptions than energy consumption and greenhouse emissions. A ten-year review for chemical engineering should cover more than process industries given the wide-ranging employment and influence of chemical engineers.

Society through networking and information flow, is interacting more directly with chemical engineers, becoming increasingly more vocal in the debate on environmental safety and ethical issues associated with the type of work that chemical engineers do. The relationships with the community need to be rooted in notions of mutual respect. It is dangerous not to listen to the public. However there has not been much in the way of change yet, in terms of the way in which the chemical engineering profession interacts with the community. The current focus is still on meeting forced (regulatory) compliance. The challenge for chemical engineers is that the changing content of technology is also seeing a change in the content of the corpus of chemical engineering. The community is being vocal in traditional areas of clash with science and engineering, such as health, safety and environment. With these changes to the content of engineering new areas for concern are emerging. The engineering community is reacting to these clashes and realises that doing nothing is not smart but being proactive is effective and strategic. Communication, engagement and discussion are the keys to any framework for interaction with the community. The ability to communicate information and ideas rapidly and to a broad audience is the common thread linking social and technical change.

There have been many advances, driven in part by market forces and in part by co-development of regulatory targets and pathways. However, less progress has been made where these forces have not been at work, most noticeably in 'tragedies of the commons' (chemical engineers are the 'they' that 'they' are blaming – chemical engineers are guilty by association with the industrial interests they are seen to serve).

Whilst most information suggests sustainability is the future for engineering, an alternative perspective is that it is not a key role for engineers to fill. Those suggesting this do so because they believe the global community has not united to address the implementation of sustainability. Sustainability's lack of economic viability means it is a non-event and the idea of the triple-bottom line is a catch-cry for companies who, in reality, focus strongly on the economics portion. The cause of this problem is that research into sustainable solutions is funded by organisations that have a vested interest in the rules of economics, which often favours unsustainable behaviour. Thus from this perspective, sustainability is hindered by the research community which instead focuses on wealth creation.

There are difficulties in measuring sustainability, which flows on to problem identification and solution evaluation. The argument here is that engineers can look at a scenario and acknowledge that change to the process will make it more sustainable but cannot define sustainability in absolute terms. Ultimately, without standards or an absolute definition, people can easily be lulled into the idea that they are acting in a sustainable manner. This suggests the only future for engineers to enhance sustainability is determining measures of sustainability. However, the challenge is ensuring measures correlate with society's view of what should be sustained and requires interaction and approval from society.

From this perspective, the final point made is that engineers may simply have to accept that a product or process may be unsustainable and changes in chemical engineering skills to better meet society's needs may still not be enough.

Societies have been instrumental in defining the code of conduct – particularly with regard to matters of health and safety. Certification is becoming an even more rigorous process as the community's expectations of what engineers deliver is rising. Recognising this, the 1997 London Communiqué acknowledged the need for chemical engineers to minimise their adverse impact on the environment and, whilst it is a wonderful start, it is a long way from a complete code of practice. The Communiqué states that chemical engineers are to use their skills to improve the quality of life: foster employment, advance economic and social development, and protect the environment – a challenge that encompasses the essence of sustainable development. Specifically this group outlined the ideas that chemical engineers will:

- Design processes and products which are innovative, energy efficient and cost effective, make the best use of scarce resources and ensure that waste and adverse environmental impact are minimised
- Achieve the highest standard of safety in making and using products of all kinds
- Provide processes and products which give the people of the world shelter, clothing, food and drink, and which keeps them in good health
- Work with other disciplines to seek solutions
- Engage in honest and open dialogue with the public on the challenges presented by manufacture of the products which the public requires
- Promote research to allow the profession to respond fully to global demands
- Encourage the brightest and best young people into the profession, and promote lifelong professional development
- Therefore we must co-operate together and recognise each other's efforts in striving to meet this challenge
- We acknowledge that this challenge cannot be met by our efforts alone, but this does not lessen the responsibility to pursue it.

Proactive commitment by chemical engineers for these ideas is possible. It can occur most readily when engineering societies and institutions adopt a strategic framework whereby practising chemical engineers commit to the London Communiqué in order to retain their licence to operate; courses to be accredited base teaching on a strategic framework for sustainability; the profession actively communicates with the wider public; commitment is obtained by implementing a framework that is supported and promoted.

Chemical engineers face major and numerous challenges on the path to sustainability. For example, the development of ability to produce food for the world has come at a number of costs to sustainability. It is widely recognised that land is being desertified by salinity and clearing at such a rate that, if continued, would ultimately threaten the ability of future generations to meet their food needs and will threaten biodiversity through the loss of habitat.

Developing scenarios often calls for seemingly contradictory paths to be pursued simultaneously, where shared understanding of this type of ambiguity is essential for path finding. Chemical engineers have a particular role to play that goes beyond merely a useful set of skills and to contribute to the leadership and decision making of the societies in which they operate.

Undeniably, chemical engineering must evolve to better accommodate sustainability in process, practice and overall mentality. Interestingly, in a survey of undergraduate students (worldwide) conducted by David Shallcross and academics at Surrey University, an attempt was made to see what understanding undergraduates had of sustainability. The survey revealed that on a scale of 1 (low) to 5 (high) the students scored below 2 in many cases with an average of 2.3.

One proposal to combat this lack of understanding is that as part of IChemE's accreditation process the topic of sustainability be built into chemical engineering courses rather than as a non-core module. Currently in IChemE's Accreditation Guidelines, Learning Outcomes in the CORE chemical engineering include under 'Systems' the statement 'The graduates must understand the principles of sustainability. They must be able to apply techniques for analysing, throughout the lifecycle, the interaction of process, product and plant with the environment'. However, the question is raised on the current effectiveness of such teachings.

In chemical engineering, advancements are occurring at the basic level by introducing sustainable development priorities into chemical engineering education. However the dilemma for undergraduate training is how to provide a thorough specialist engineering education while also preparing engineers to make innovative contributions to emergent outcomes in networks.

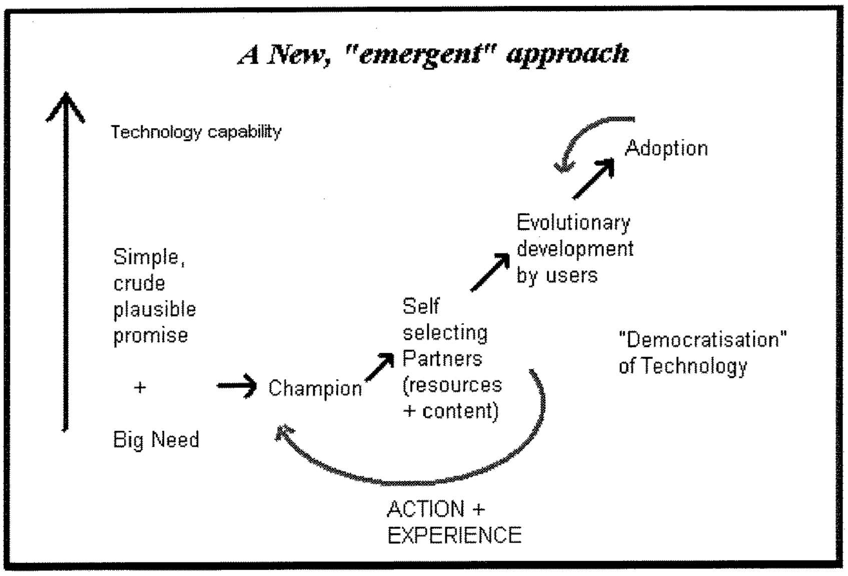
Technically, chemical engineering fundamentals have not changed, but the way that they are applied is now more widespread. The key directions for chemical engineers include; championing developments that reduce the tragedy of the commons (leading rather than following regulations); seeking options rather than singular solutions (presenting as many sensible options as possible that are innovative, and increasingly emergent from constructivist approaches); emphasise widespread networks (collective discussions and fostering collaboration).

In order to integrate sustainability into the industry and the global community, a new approach is required. The concept of sustainability has become widely accepted as a uniting and purposeful focus for the 21st century. The challenge for chemical engineering is to evolve to suit this new context, so that it may continue to make a valued and knowledgeable contribution, emerging as a more sustainable profession. The challenge of sustainability will be supported by our traditional skills, but it will not be met by more efficiently doing what has led to success so far.

A summary of the approach to chemical engineering that will best support sustainable development involves:

- Science and technology: humble tool for knowledge, prediction, and control, not 'truth and glory'
- Aim: practical means of achieving perceived 'sustainable' benefits
- Creative Emphasis – Collaborative 'constructivism', not 'construction'
- Breadth – Global, networked
- Action – Emergent, local, 'inform'ed
- Tolerance for Ambiguity – Gelling, multiscenario, not crystallising, 'the best path through a forest of realities'
- Ingoing dissonance – assisting effecting action (rather than retarding efficient action), reducing 'the tragedy of the commons'

This would be aided by a new way to approach the design and solutions of problems;



The contribution of chemical engineers has evolved more to that of options provision than problem solving, since the more important problems are not ours alone to solve. It is likely that organisations that seek the services of chemical engineers will evolve gatekeeping systems that demand greater networking ability and tolerance for ambiguity.

Clearly, sustainability needs attention and chemical engineers are in a unique position to provide options for the future, as the nature of the discipline is primarily reductionist, deductive and deterministic. Professor Bridgewater has stated that chemical engineers know much about how to cope with processing and with systems, and how to deal with uncertainty. Indeed the role of the chemical engineer is becoming more vital to society. Engineers know how to take relevant information, incorporate it with best practice – having due regard to economics, safety and the environment – to yield both a process and a product that takes account of life cycle analysis and satisfies the needs of the community.

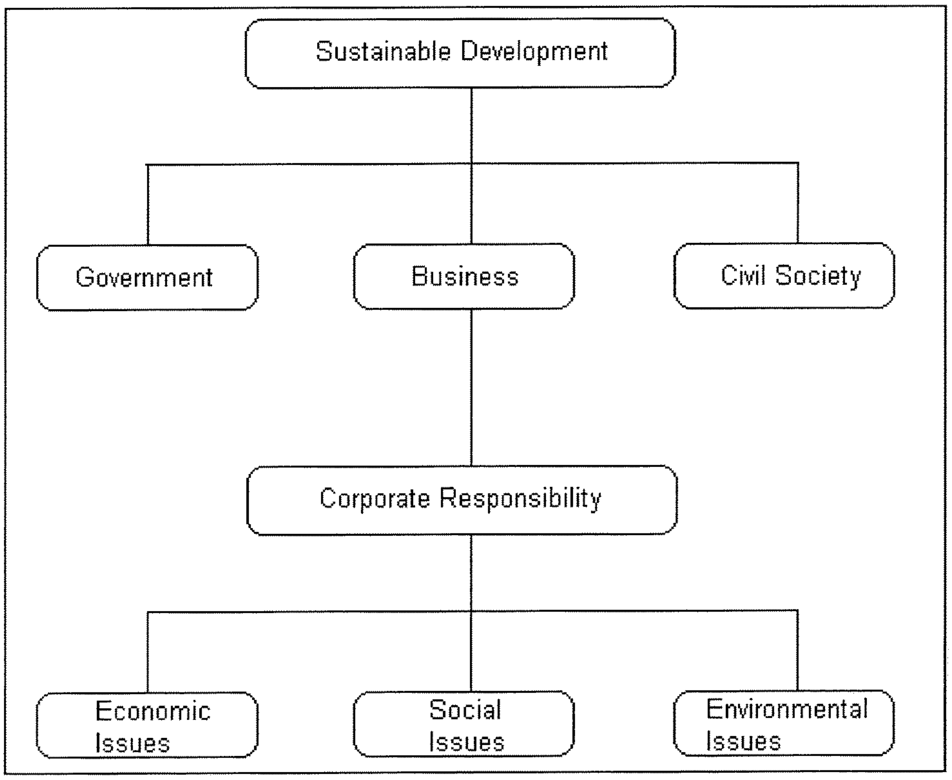
Ultimately a sustainable future for chemical engineers is a developing process which is an identifiable and energetic profession built on traditional strengths and recognising new challenges. It also requires a new generation of engineers that are trained to adopt a holistic view of processes as embedded in larger systems. Engineering is no longer performed in isolation, where consideration is expected for industrial processes, and human and ecological systems. The quest for sustainability requires research and educational innovation and advance in engineering, management, economics and sociology disciplines.

Rio Tinto encapsulates their idea on sustainability by suggesting the underlying principle is very simple - they are in the business to create value for their shareholders, responsibly and sustainably. This is approached as a long-term optimisation exercise where maximising the long-term value of the business will ultimately be reflected in their share price and aims to achieve financial success and social responsibility.

When a business decides to align itself in accordance with the concept of sustainable development, the decision has been driven by a judgement regarding long-term business benefits in terms of lowering risks, reducing costs, creating options, and leveraging reputation. By encouraging all sectors of the business to understand the implications of the concept within their specific social, environmental, economic and governance circumstances, the approach has the advantage of giving local meaning to the business' global sustainable development effort. This is likely to lead to more locally relevant and successful outcomes.

Effective communication with communities is one of the cornerstones of sustainable development in business sectors; through it there is the aim to build a corporate reputation for honesty, integrity and fair dealing. Through social and philanthropic activities, corporations strengthen the vitality of the communities to which their employees belong. In addition, businesses need to build into their plan provisions of essential infrastructure; this is integrated with the need for a regional development plan that anticipates the potential impacts of a company's presence in the local area.

Sustainable development is only meaningful on a national or global scale, therefore it is beneficial to examine where business contributes to sustainable development (demonstrating the links between government, business and civil society). Business mainly contributes through wealth and job creation as well as the provision of goods and services; it is also involved through diverse contributions to government and civil society – or corporate responsibility.



There is a rising expectation on the part of the community that social matters will be given the same level of support as health, safety and the environment. It has created a new set of market forces (increasing the need for strong channels of communication):

- Social funds that invest in corporations based on social and environmental criteria
- Shareholders' expectations of improved returns, environmental performance and social responsibility
- Voters' expectations of commitment to sustainability and development of Government support for certain programs
- Alliances between businesses, NGO's, Governments targeting the need of all parties

Therefore the desire for greater sustainability results in these market forces but also in political forces that have demanded leadership from corporations and governments. These forces are impacting on primary materials consumption and the work of the corporations supplying these materials.

As well as businesses finding ways to include sustainable development principles in their business plans and decision making and investigating how social, environmental, economic and governance issues can be integrated, they need to determine what sustainability means to them and actively engage with their stakeholders to ascertain perceptions and beliefs and consider appropriate measures, targets and reporting requirements.

A sustainable development issues survey identified five key attributes which were considered to be the most important by Rio Tinto's stakeholders: commitment to safety; responsible business ethics and corporate governance; excellence in environmental management; demonstrating high-quality management; and open and honest communication with the public. In addition, opinion leaders believed the most important environmental issues are (for a company that focuses on mining): ensuring the sound rehabilitation of areas disturbed; managing mineral and non-mineral waste; and improving efficiency in water use. Linked with this is the encouragement of sustainable communities and appropriate consideration for Aboriginal and Torres Strait Islander people.

The march to sustainability can be measured in many ways, for example through global performance measures, reporting and the influence of regulation.

International corporations have initiated uses of pilot programmes to help understand, measure and maximise the contributions made from operations to sustainable development. A typical program will use the basic principles of environmental stewardship, social wellbeing and economic prosperity.

Organisations recognise that in order to expand sustainable development principles beyond the confines of Environmental Health and Safety and Communities Departments, they must involve experts and 'champions' from throughout the organisation, including core business groups like operations, technology and commercial. Initiatives include a sustainable development 'champion' and cross-functional teams where sustainable development is a global concept with local meaning. Due to the very diverse nature of industries, a 'one-size-fits-all' approach will not work. Varying circumstances in terms of communities, environment, commodities, markets and scale mean that local solutions have to be found.

Often when a company decides to make sustainable development a mainstay of the business, there needs to be reconsideration of existing strategies. This then creates the challenge of moving forward where there needs to be a transition of sustainable development from a project to a business imperative. Businesses need to investigate how they can contribute to sustainable development, with management aligned to its principles. More is needed to integrate sustainable development concepts into core business activities. The focus on sustainable development needs to be sharpened by enunciating some concrete objectives. The bottom line is to add value by integrating sustainable development concepts and solutions into all operations, products and opportunities.

One perspective on enhancing sustainable development is that a central focus on value creation is now a more effective way of creating business action on sustainability than a primary focus on

the 'moral imperative'. Sustainability will be achieved more rapidly by business if the profit motive becomes the dominant driver and framework for analysis rather than 'corporate social responsibility' in its various manifestations. The idea of operationalising sustainability is underpinned by two assumptions – that the current economy is not sustainable where its trajectory poses serious threats to the stability of our social and global eco-system and; to rectify this, global market forces need to be mobilised so that the pursuit of sustainability aligns with the pursuit of growth, profit and competitive advantage.
From this perspective of sustainability, value needs to be the central organising basis for corporate sustainability. Creating value – and reporting it at the financial bottom line using accepted accounting and reporting approaches – drives change in business further and faster than anything else. Crucially, in the sustainability context, this change can happen at a speed and a scale that quickly impacts on the whole global economy and society. Ultimately companies who will succeed - enjoying decisive advantage and acceptance by the wider society - will be those who make sense of their environment, generate strategic options, and re-align resources faster than rivals in the pursuit and achievement of sustainability.

Generally, there is value at stake for most companies in most industries in their performance and positioning on environmental and societal issues, therefore if value is at stake in sustainability, successful strategies to manage sustainability will create value.

Sustainability has traditionally been positioned as a moral imperative and obligation where companies have been urged to not focus on the 'ruthless pursuit of profit', but should pursue other options as well. This effectively says those other options are not profitable, and therefore sustainability has been positioned against value. By applying this moral imperative approach, Corporate Social Responsibility immediately implies obligation to do things that are against what business wants to do. A result of this is that anything not in harmony with the pursuit of value and growth will soon be relegated to a second or third tier priority for business. Sustainability cannot be here – it needs to move to centre-stage for business decision-making and the concept of the triple bottom line can be a disadvantage if companies try to use it for business strategy. It can often swing to the financial focus making it a very slow change agent, however if companies create more social and environmental value the right way they will create more financial value as a direct and measurable result.

This has created a shift in thinking due to the growing recognition among business executives that profitability alone is inadequate as a measure of success, and that many nonfinancial concerns associated with sustainability are fundamental drivers of long-term shareholder value.

The primary focus on the creation of value in advocating, designing and implementing corporate strategies on sustainability is a more effective way to encourage action by business than a focus on the 'moral imperative' or social responsibility. A focus on value drives change more effectively and therefore drives more change. Using a value creation focus makes sustainability central to the mission of the organisation.

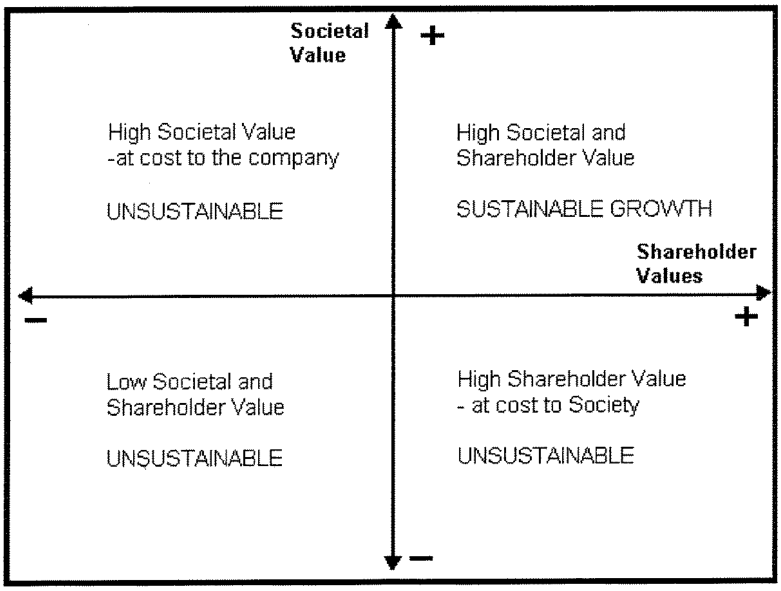
Unfortunately it is not always profitable or appropriate for a particular company to do the 'right thing' with regard to sustainability. The theory, which focuses on value, does not address this problem but it will not exacerbate it either. However, it is not a less effective option than the morally inspired socially responsible approach to sustainability (which will not result in a company pursuing a strategy that is against its commercial interests).

It is well accepted by business analysts that sustainability describes a very useful framework for management to think about their business and their marketplace. It is also increasingly clear that strong performance in sustainability, on average, is associated with stronger financial performance. Sustainability it not a business strategy by itself; it is an addition to and perhaps an indicator of, but never a replacement for, high-quality leadership and management. Under this theory, a focus on value is believed to be the best way to avoid the risk of a potential disconnection between sustainability leadership and good basic business management. The challenge is how to approach sustainability in ways that create the most value and therefore encourage the most active uptake of these ideas by the business community.

The guiding principles, which frame the approach to making value the starting point in corporate sustainability, are:

1. Focus on value from the outset; be clear that value creation is the objective
2. Think of value broadly
3. Identify the value case; understand the value at stake in sustainability first generally, and then for your company in your industry and marketplace
4. Reach beyond your traditions value chain to find greatest value
5. Evaluate possible strategies against their potential to create or protect significant value for your business
6. Apply simple rigor to the process
7. Don't argue the value case; create value, demonstrate how you did it, and explain how you will do it in the future

In the large part, corporate sustainability is about aligning the business and its products (and therefore the creation of shareholder value) with society's values. A sustainability strategy guide helps companies review both their current business activities and proposed sustainability initiative to ensure strategy is more robust across the board.



Single Bottom Line Sustainability develops a framework and practical tools for creating value through sustainability by blending it directly into business decision-making. It puts sustainability squarely in the centre of what business does best – making money and growing. Recent studies suggest three major pathways for sustainability to contribute to shareholder value; contributing directly to tangible financial value by enabling growth, reducing costs, conserving capital, and decreasing risks; improve intangible assets such as reputation, strategic relationships, human capital and innovation; and provide strategic advantage by creating value for stakeholders.

Sustainability and profitability can go hand-in-hand by reducing environmental impact and increasing returns. Some industries such as CRC SSP have introduced an information kit and provided technical training to help farmers understand and manage simple process that encourage sustainability.

Questions organisations ask and try to answer to enhance sustainable practices include: how do we create a framework to ensure that projects culminate in a new way of doing business, not just a report?; what measurements of our current performance – social, economical and environmental – are germane to sustainable development principles?; how do we report – and foster commitment among – employees and external stakeholders?

The force of competition means that it is not long term 'sustainable' to be left behind. The result is a synthesis of the 'old' and 'new' market forces, with competition at least in part focused on more sustainable outcomes. Even at the individual business level, networks that involve government, industry, research and environmental interests are being established to advise on the level and effectiveness of efforts. These initiatives often involve public reporting.

Reporting is a practical and specific action that brings significant benefits compared to the costs of doing it. Reporting teaches companies more about their own business, and thus identifies opportunities for savings. It is a good starting point in the pursuit of sustainability – but that is all (a starting point). Too many companies now seem to view reporting as their sustainability strategy, rather than a tool for self-awareness and education.

For some, financial reporting can be more useful than triple bottom line reporting as it drives behaviour not solely because it is disclosure, but because of the positive and reinforcing feedback impact on shareholder value. It is this alignment between the interests of investors and management that makes financial disclosure powerful.

Another framework for enhancing sustainability is the Global Reporting Initiative, which is about indicators for measuring economic, environmental and social impact – regulatory in nature, but a voluntary exercise. It establishes a global presence and a credible guidelines-setting process for environmental reporting. There have been comments made that this process does not offer direction on how to then go about improving process and systems in order to achieve sustainability. What it suggests is that this is a good framework to couple with others in order to achieve, maintain and improve on a company's sustainable development.

IChemE's Sustainability Working Group took a step in the right direction with the introduction of its Sustainability Metrics package, completed in May 2002. The group acknowledged that sustainable development is a noble principal, but one that is difficult to quantify. Therefore the Metrics package is designed to gauge the sustainability performance of an operating unit within the chemical and process industry. In the past, due to the difficulties associated with measuring sustainability progress, it was often an area avoided by many industries. However the metrics provide engineers with a practical toolkit for measuring progress broadly using information that is already available. The methodology is simple and integral to the production process. Effective measurement now opens the way for effective management.

Ideally, sustainability metrics should be easy to calculate with available data, useful for decision-making, reproducible, scientifically rigorous, useable at multiple scales of analysis, and extendable with improved understanding

Additional innovative business practices that have assisted the pursuit of sustainability include a design for sustainability. This is a systematic consideration, during design and development, of sustainability over the full product and process life cycle. Eco-efficient manufacturing focuses on reducing the 'ecological footprint' of a company's operation (including materials inputs, natural resources, and energy required to manufacture and deliver a unit of output). Industrial ecology is a framework for shifting industrial systems from a linear model to a cyclical model that resembles the flows of natural ecosystems. Then within this area there have been efforts to evaluate each dimension of the 'triple bottom line' independently and to varying extents. It has been implied that economic profits need to be 'balanced' against environmental and social benefits, whereas these three aspects of corporate performance are inseparable and whilst advanced independently must re-merge (avoiding evaluation of each feature independently).

With reference to Process Systems Engineering, noted as a strong potential driver of sustainability, a systematic framework is essential for developing PSE. It should be applied to all stages of the chemical value chain, and for every process engineering task. It would aim to evaluate the sustainability of existing processes and products to identify retrofit opportunities, and for quick screening of alternatives; operating existing processes and their value chains in a sustainable manner; guide the development and evaluation of the sustainability of new technologies; and design and evaluate novel unit operations, processes, and networks of industrial ecosystems. There is the need to be moving in a much more determined manner towards the notion of processing of products designed for whole-of-life cycle – with minimum or no waste, aided by the implementation of a framework for PSE.

The pursuit of sustainable development with a system approach, such as PSE, to the design of industrial products and service systems remains challenging because of the broad range of economic, environmental and social factors that need to be considered across the system life cycle. Consequently, whilst many business enterprises have adopted sustainability goals, the actual development of sustainable systems is not as advanced.

For corporations, which have adopted sustainable business practices, the most common reasons cited were enhanced reputation, competitive advantage, and cost savings. Other factors that drive this trend include increasing emphasis on corporate ethics and accountability, including social responsibility and transparency. But to be truly effective, approaches need to create robust frameworks based on an agreed set of broad principles; understand the key challenges and constraints facing the industry and the actions possible to overcome them; provide a process for responding to these challenges that respects the rights and interests of all involved; includes an integrated set of policy instruments to ensure minimum standards of compliance as well as responsible voluntary actions; and has verifiable measures to evaluate progress and foster consistent improvement. However, despite the heightened awareness and commitment of sustainability, many companies have found it difficult to transfer broad goal and policies into day-to-day decision-making.

The concept of resilience enables sustainability to be viewed as an inherent system property and process rather than an abstract goal, making it easier to transfer ideas into actions. The four major system characteristics that contribute to resilience are: *diversity* (existence of multiple forms and behaviours); *efficiency* (performance with modest resource consumption); *adaptability* (flexibility to change in response to new pressures); and *cohesion* (existence of unifying forces or linkages).

Historical research has identified that sustainable enterprises or long-lived companies have four distinguishing factors:

- Sensitivity and adaptability to the business environment
- Cohesion and sense of identity
- Tolerance of diversity (decentralisation)
- Conservative use of capital.

Notably profitability was not a factor and is considered an outcome rather than a predictor. In the same research, the main determinants of superior performance were not technology-based but rather organic system traits (being features of culture, structure, strategy and execution). Company characteristics such as human capital, innovation, alliances, and brand equity, are increasingly viewed as leading indicators of shareholder value. Paying attention to social and environmental performance strengthens many of these intangibles. Therefore a sustainable enterprise is one that continues to grow and adapt in order to meet the needs and expectations.

At a very fundamental level and reducing the complexity of frameworks already discussed, adopting sustainability scorecards is an option for organisations. A scorecard breaks down the areas affected by a process such as economic, environmental, health and social and through comprehensive questions in each area it can be used to facilitate rigorous community exploration of the costs and benefits of various options before them. Ultimately, a scorecard evaluates the sustainability of a process and enables the most appropriate one to be selected. Using the Sustainable Development Principles as outlined in The Mining, Mineral and Sustainable Development Report is an effective way to formulate the scorecard and what is to be addressed in each area:

Sustainable Development Principles – A Scorecard Basis

Economic Sphere
• Maximise human wellbeing.
• Ensure efficient use of all resources, natural and otherwise, by maximising rents.
• Seek to identify and internalise environmental and social costs.
• Maintain and enhance the conditions for viable enterprise.
Social Sphere
• Ensure a fair distribution of the costs and benefits of development for all those alive today.
• Respect and reinforce the fundamental rights of human beings, including civil and political liberties, cultural autonomy, social and economic freedoms, and personal security.
• Seek to sustain improvements over time; ensure that depletion of natural resources will not deprive future generations through replacement with other forms of capital.
Environmental Sphere
• Promote responsible stewardship of natural resources and the environment, including remediation of past damage.
• Minimise waste and environmental damage along the whole of the supply chain.
• Exercise prudence where impacts are unknown or uncertain.
• Operate within ecological limits and protect critical natural capital.
Governance Sphere
• Support representative democracy, including participatory decision-making.
• Encourage free enterprise within a system of clear and fair rules and incentives.
• Avoid excessive concentration of power through appropriate checks and balances.
• Ensure transparency through providing all stakeholders with access to relevant and accurate information.
• Ensure accountability for decisions and actions, which are based on comprehensive and reliable analysis.
• Encourage cooperation in order to build trust and shared goals and values.
• Ensure that decisions are made at the appropriate level, adhering to the principle of subsidiarity where possible.

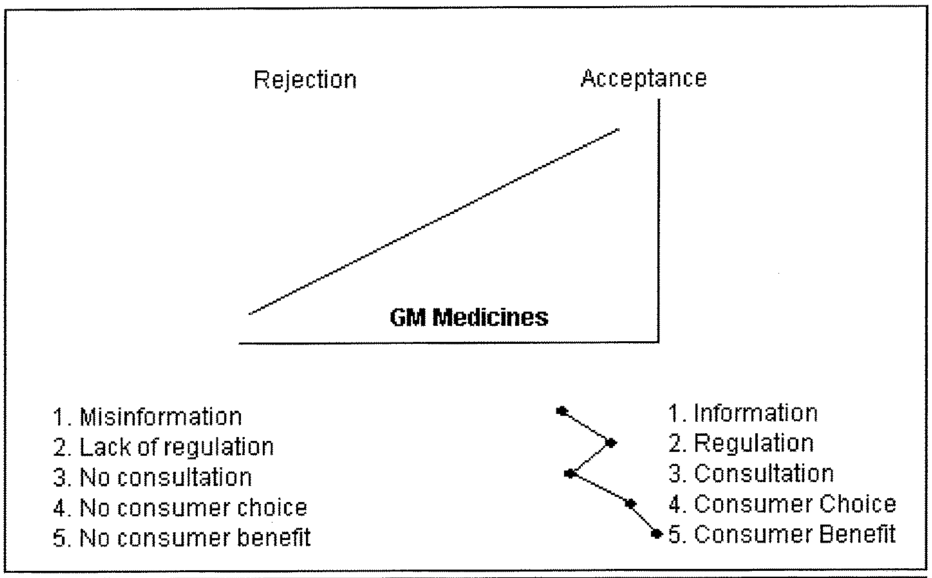
Coupled with a Sustainability Scorecard, particularly in systems approaches, sustainability indicators that have been commonly used to characterise the performance of outcomes include:

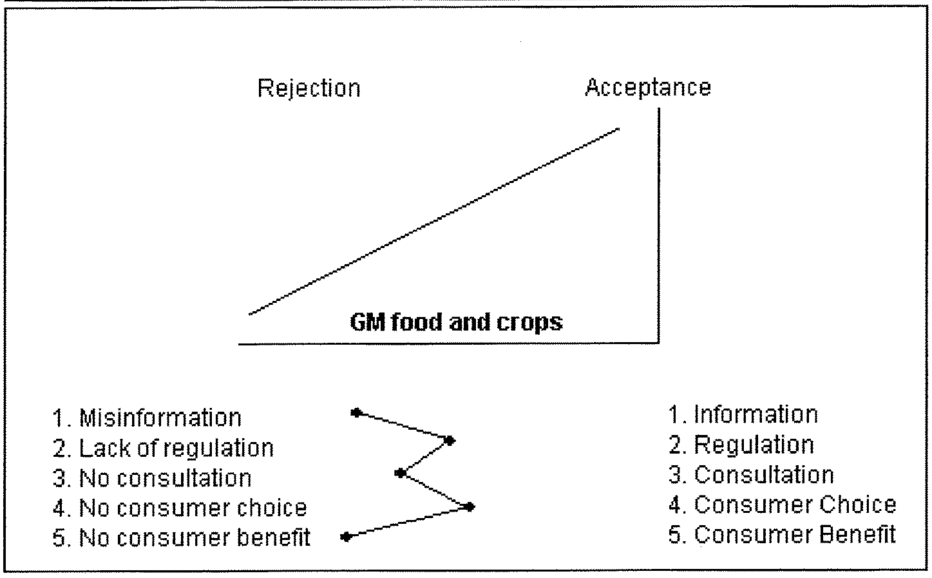
Examples of Conventional Sustainability Performance Indicators

Economic	*Environmental*	*Societal*
Direct • Raw material costs • Labour costs • Capital costs • Operating Costs	**Material Consumption** • Product & packaging mass • Useful product lifetime • Hazardous materials used • Eco-efficiency	**Quality of Life** • Breadth of product or service availability • Knowledge enhancement • Employee satisfaction
Potentially Hidden • Recycling revenue • Product disposition cost	**Energy Consumption** • Life cycle energy • Power use in operation	**Peace of Mind** • Perceived risk • Community trust
Contingent • Employee injury cost • Customer warranty cost	**Local Impact** • Product recyclability • Run-off to surface water	**Illness & Disease Reduction** • Illnesses avoided • Mortality reduction
Relationship • Customer retention • Business interruption due to stakeholder interventions	**Regional Impacts** • Smog creation • Acid rain precursors • Biodiversity reduction	**Safety Improvement** • Lost-time injuries • Reportable releases • Number of incidents
Externalities • Ecosystem productivity loss • Resource depletion	**Global Impacts** • Global warming emissions • Ozone depletion	**Health & Wellness** • Nutritional value provided • Subsistence costs

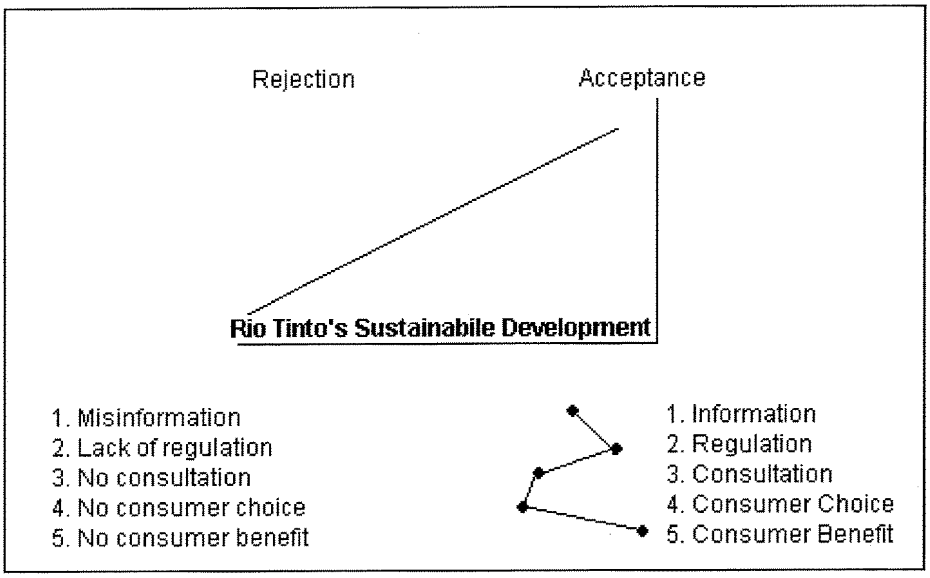
The Global Reporting Initiative has developed a more exhaustive catalogue of performance indicators as part of its sustainable reporting guidelines.

What organisations need to be aware of is that sustainability is difficult to quantify and its perception of improvement is often heavily influenced by the community and society's acceptance of the changes made or the results obtained. An interesting comparison is using research into genetically modified products:





This analysis could be used on the public's perception of an organisation's sustainability. It could be done for the organisation as a whole or just an individual process that the community is aware of. Using a paper released by Rio Tinto for Sustainable Development Issues Survey 2003 the following graph was developed:



When analysing the sustainability of industries, it needs to be emphasised that the requirements will vary greatly across industries. The target or purpose is ultimately to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future (as outlined by the World Business Council for Sustainable Development), yet the means of achieving this differs. Natural resource extractions industries (mining, oil production, agriculture, and forest products) may emphasise appropriate land use, ecosystem protection and worker safety. Industries further downstream in the supply chain, such as petroleum refining, metals, chemicals and electrical utilities might emphasise process safety, conversion efficiency and waste minimisation. Industries close to the end-customer might emphasise environmentally conscious packaging and responsiveness to social needs. Finally service industries might emphasise efficient logistics or human resource development.

Mining industries are trying particularly hard to replace images of social destabilisation and environmental destruction that are a part of the mining industry's legacy; and to compete with the daily reinforcement of the link between industry and some of the culture's most difficult issues – overuse of resources, habitat loss and irreversible pollution. As sustainable development belongs to the future the industry needs to 'mine smarter' – for example, with reduced use of energy and water, and less waste products.

But the questions are then raised on whether mining can be made truly sustainable in terms of its costs to society and the environment? Truly sustainable mining starts long before mining itself, in the outlook and behaviour of people who pave the way for new mines. Advanced mining companies integrate sustainable development into every stage of their work where they prioritise (explore for what is most wanted), communicate (transparency wins friends especially among local communities), protect (health, safety and the environment) and contribute (improve lives, improve the future).

Ore extraction can result in transformations that create lasting social, economic and environmental capital, not only meeting current needs but providing the 'hardware' and the 'software' to enable future generations to live to far higher standards than could otherwise have been attained. This can be achieved with diminishing impact on the planet's life support systems as technology improves.

The Mining, Minerals and Sustainable Development (MMSD) report directs the mining, metals and minerals industry towards a future of:

- greater engagement with those outside
- of shared problem solving with others
- and reveals the complexity of the land beyond the horizon

It essentially attempts to demonstrate how to improve social, environmental and economic performance and to ensure the sector conducts itself in keeping with the expectations of contemporary society. The objectives of this report recognised that it is crucial for long-term impact, to build platforms of analysis and engagement for ongoing cooperation and networking among all stakeholders.

In this report there are descriptions on what the mineral sector should look like to maximise its contribution and sets out four steps: understanding sustainable development; creating organisational policies and management systems; achieving cooperation among those with similar interests; and building capacity for effective action at all levels. The key recommendation is that industry develops a protocol for sustainable development with clear and measurable benchmarks for improvement of performance with incentives to encourage change. The nine key challenges facing the minerals sector are the viability of the minerals industry; the control, use and management of land; minerals and economic development; local communities and mines; mining, minerals and the environment; an integrated approach using minerals; access to information; artisanal and small-scale mining; and sector governance (roles, responsibilities and instruments for change).

The MMSD analysis clearly states that the challenges of a sustainable mining and metals industry cannot be achieved by the industry alone, there must be active engagement and commitment by other stakeholders – national governments, local community representatives and other interested parties. Ultimately the MMSD report is a reflection of community perceptions about the industry and its contribution to sustainable development.

Implementation of sustainable development principles and adherence to an MMSD requires the development of integrated tools capable of bringing these diverse objectives into focus. Instruments available for this include regulatory, fiscal, educational and institutional tools where it is important for actions to be SMART (specific, monitorable, achievable, realistic and time-bound)

It is hopeful that, in time, the once through usage pattern that characterises mining, metal production and metal use will change to a process of continuous use and recycling where the only input to the cycle is renewable energy. Whilst technology is a long way from achieving this goal, progress is being made now.

The MMSD is a specific mining industry example of one means of working towards sustainability. Some generalisations can be made with regard to the areas that similar methods for other industries must address in order to be useful. They must consider the need society has for the commodity; the structure of the sector; exactly who are all the stakeholders; subsidiarity (such as local issues being solved locally); best practice and actions taken at the appropriate level; incentives for change; capacities where sustainable development calls for a new and different mix of skills; managing industry wealth; developing the legacy of the industry and the social perception; collective efforts by all businesses in the industry/sector; and finally the use of existing institutions.

Again on general terms, the four major categories of actions to support sustainable development are:

- Widespread, increased understanding of sustainable development
- Create organisational-level policies and management systems for implementing the principles of sustainable development
- Collaborate with others with common interests to take joint steps towards sustainable development
- Increase the ability to work towards sustainable development at the local, national, and global levels.

As a part of developing frameworks and implementing strategies, it is necessary to address the challenges of sustainable development at different levels. For example, climate change is a global issue, whilst others such as regulatory changes are national issues and finally resource use is at the local level. This way the people the issue is most relevant to directly deal with it, increasing community involvement, productivity and acceptance of change.

Another branch of sustainable development is the numerous strategies on how to manage biodiversity; these issues will become an increasingly important part of securing continued access to land. Biodiversity issues need to be fully incorporated into all business decisions.

There are many major challenges faced on the path to sustainability, where innovation is still the ultimate driver of improvements. Technological development increasingly requires cross-cutting, large, well equipped interdisciplinary teams.

The Australian Government sees its role in sustainability to include national research with a focus on aspirational goals of an environmentally sustainable Australia through areas like reducing and capturing emissions in transport and energy generation. Several common themes influence the science and innovation agenda in Australia. Firstly there is the link between peer-reviewed scientific evidence and commercial application and second is the rise in multi-disciplinary research (where sustainability issues are best analysed by combining expertise from two or more disciplines.

At the Global Energy Technology Strategy Project in October 2003, the United Nations Framework Convention on Climate Change was discussed. Its three key elements aimed to: stabilise concentrations not emission levels; prevent danger; and allow economic development to proceed in a sustainable manner. This indicates how sustainable development is actively addressed by organisations and plans used to achieve objectives.

Locally there is a focus on the environmental effects of wastewater disposal and recycling, where it is important to understand the material and energy cost involved with new innovations. The challenge is to create a way to fairly compare the environmental impacts on various parts of the ecosystem so that the most sustainable option can be adopted (one which meets the needs of the triple bottom line whilst having the forethought to future generations).

Whilst company examples, annual reports, global research and countless frameworks suggest that there is a shift in perceptions – and actions – towards sustainability, the question remains on how one measures the successful implementation of sustainability. Is a company acting sustainably if its actions meet the Bruntland definition? Or is there a greater need for global standards as measurements of sustainability? This would need massive resources and stringent control to ensure standards are accurate, adequate and evolving so they are applicable now and in the future.

One possibility, that could reach a Global Scale, is establishing a Sustainable Development Support Facility to serve as a central clearinghouse for information on who is doing what in a particular sector and to suggest ways to coordinate and target the efforts of businesses. By establishing a key body for each major industry area they could serve:

- As an independent source of capacity building or advice to government on issues arising out of sustainable initiatives
- As a supplement to government departments charged with technical tasks linked to the industry
- To help develop the technical standards necessary for effective impact assessment
- To assess the potential new methods of practice by industry
- To assist in the development and strengthen the capacity needed for effective planning for closure on projects
- To implement global measurements for quantifying sustainability

It is a body that could be supported by donor agencies, and could be administered by a trust fund.

The idea of resilience can also tie in with the triple bottom line and a new field of research is ready to be explored where ultimately sustainability cannot be achieved without stability between economic, environmental and social factors. Exploration of this field, for example, would identify how advances in environmental factors affects the economics of the organisation and if it ultimately drives sustainability forward in the long term. This can then flow onto models and untouched territory of how to improve sustainability through systems showing the rate of change tolerated in any of the three prime directions to assume an overall sustainable and successful position.

For chemical engineers, it seems that a debate in realities has been reached. According to research, the majority believe that sustainability is a serious concept and globally organisations are incorporating and refining it in their practices. It is now the task of organisation such as IChemE to shift perceptions, so that those who claim sustainability is just a catch-cry and not a significant role for engineers to fill are exposed to unbiased information that demonstrates the importance and real ways for sustainability to be achieved. A research group within the IChemE organisation which focuses on sustainability at a community, industry and tertiary education level would be paramount in moving both engineers and the world forward.

REFERENCES:

Adeyeri, E. (2002) *'You can't manage what you can't measure'*, The Chemical Engineer, p. 66, September 2002.

Bakishi, B.K. and Fiksel, J. (2003) *'The Quest for Sustainability: Challenges for Process Systems Engineering'*, AIChE Journal, Vol. 49, No. 6, June 2003.

Batterham, R.J. and Hollitt, M.J. (2003) *'Production of Primary Metals – Towards Improved Sustainability'*, Erzmetall, No. 9, p. 519-528.

Batterham, R.J. (2003) *'The Chemical Engineer and the Community'*, Chemical Engineering: Visions of the World, p. 67-90.

Batterham, R.J. (2003) *'Ten Years of Sustainability: Where Do We Go From Here'*.

Cribb, J. (2003) *'Sustainable Production Pays Off'*, Cooperative Research Centres Association Inc, Media Release April 15 2003.

Dewulf, J.P. and Van Langenhove, H.R (2002) *'Quantitative Assessment of Solid Waste Treatment Systems in the Industrial Ecology Perspective by Exergy Analysis'*, Environmental Science and Technology, Vol. 36, No. 5, p. 1130-1135.

Dooley, J.J. (2003) *The Global Energy Technology Strategy Project'*, Joint Global Change Research Institute, Battelle, October 28 2003.

Fiksel, J. (2003) *'Designing Resilient, Sustainable Systems'*, Environmental Science and Technology, December 2003.

Gilding, P., Hogarth, M. and Reed, D. (2002) *'Single bottom line sustainability – how a value centred approach to corporate sustainability can pay off for the shareholders and society'*, Ecos Corporation.

Institute of Chemical Engineers (2002) *'IChemE Annual Review 2002'*, IChemE.

International Institute for Environment and Development (2002) *'Breaking New Ground – The MMSD Final Report'*, http://www.iied.org/mmsd/finalreport/index.html. Accessed on 8/12/2003.

Keefe, S. (2001) *'Future Focus'*, Rio Tinto Review, Number 58, June 2001.

Kyte, B. (2003) *'Sustainable power: what is it?'*, The Chemical Engineer, p. 28, May 2003.

Leggatt, H. (2002) *'Coming to terms with Sustainable Development'*, Rio Tinto Review, Number 61, March 2002.

Morrissey, C. (2002) *'Looking towards a sustainable future'*, Rio Tinto Review, December 2002.

Prime Minister's Science, Engineering and Innovation Council (2003) *'Recycling Water for Our Cities'* 28th November 2003.

Prime Minister's Science, Engineering and Innovation Council (2002) *'Beyond Kyoto – Innovation and Adaption'*, Ninth Meeting, 5 December 2002.

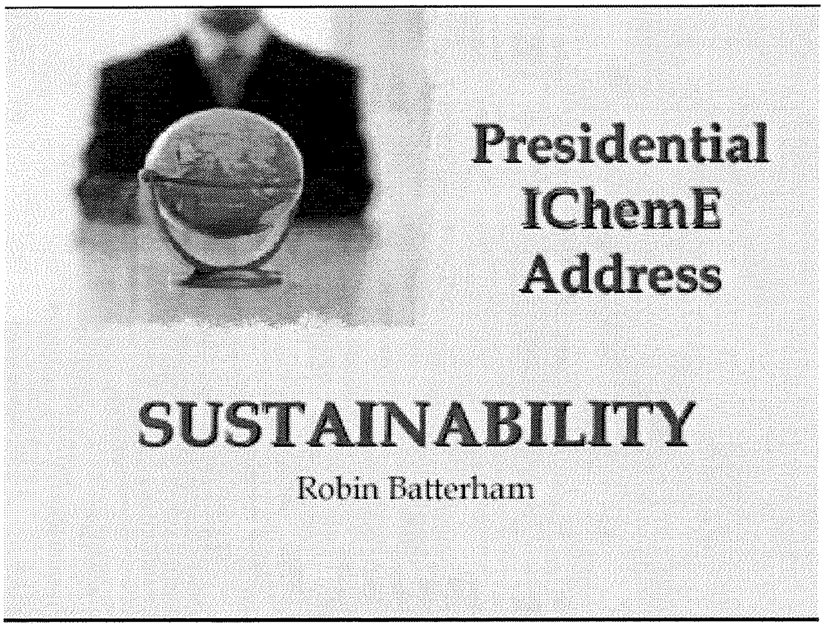
Rio Tinto (2003) *'Sustainable Development Progress Report'*, Rio Tinto.

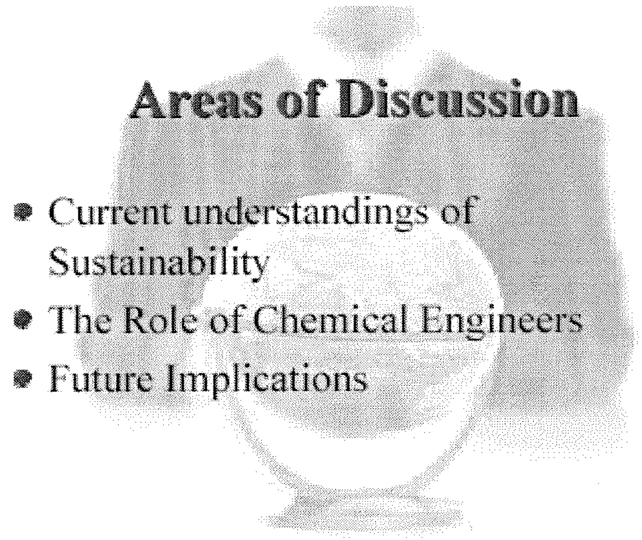
Sharratt, P. (2003) *'Sustainable Development and Technology'*, Editorial – Special Issue of Process Safety & Environmental Protection, IChemE.

Wilson, R. (2002) *'Sign of the Times'*, Rio Tinto Review, June 2002.

Wilson, R. (2003) *'Hard Times, steady progress'*, Rio Tinto Review, Number 66, June 2003.

IChemE President's Address – PowerPoint Presentation





Sir David King, the Chief Scientific Adviser to the UK Government argues that climate change is real and the causal link to increase greenhouse emissions in now well established. He argues that climate change is of pressing importance, even of more significance than terrorism and weapons of mass destruction. I would argue that sustainability is a super set and indeed more important than climate change.

Reasons for Adopting Sustainable Practices

- Enhanced reputation
- Competitive advantage
- Cost savings
- Emphasis on corporate ethics and accountability

For corporations, which have adopted sustainable business practices, the most common reasons cited were enhanced reputation, competitive advantage, and

cost savings. Other factors that drive this trend include increasing emphasis on corporate ethics and accountability, including social responsibility and transparency.[1]

[1] Bakshi, B.R. & Fiksel, J. "The Quest for Sustainability: Challenges for Process Systems Engineering", AIChem Journal, Vol.49, No. 6, June 2003.

Slide[1]

This increase in ethical investments is a growing trend observed in developed nations

[1] Babstock, C. "Ethical Investments buy corporate conscience", http://www.carleton.ca/Capital_News/04121998/i1.htm, accessed on 23/12/03.

Sustainable Finance

- London principles of sustainable finance supported by the Corporation of London
- To ensure that Socially Responsible Investment becomes mainstream
- CD project, the carbon disclosure project
  - 87 institutional investors, $9 trillion of assets
  - Disclosure on emissions from the largest 500
  - Majority responded, next response May 2004

Sustainable finance is the provision of financial capital and risk management products to projects and businesses that promote, do not harm, economic prosperity, environmental protection and social justice.

Bruntland Definition

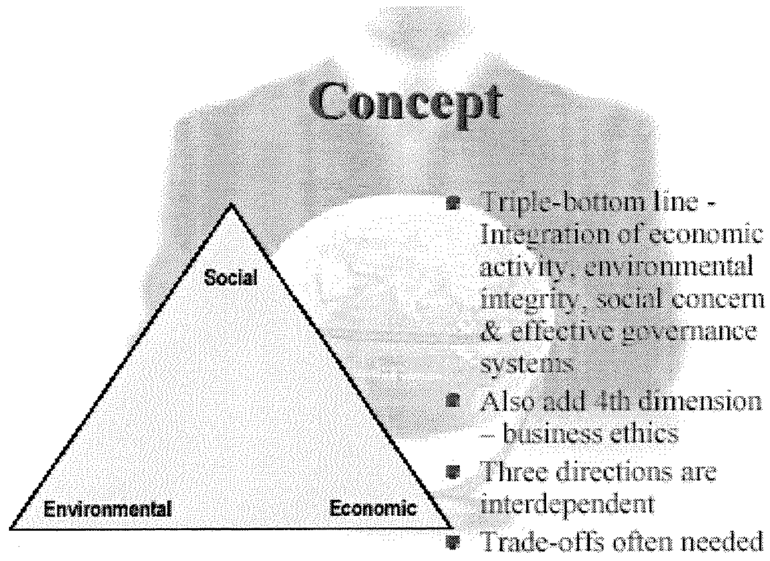
'Advance of human prosperity in a way that does not compromise the potential prosperity & quality of life & future generations'

- From this prosperity advancement can be taken for granted

Behind the Bruntland definition, prosperity advancement can be taken for granted. It is recognised however that this advancement must be managed to occur with particular constraints. If it were to be achieved in the manner of those who are already prosperous, the overwhelming evidence is that it could be short-lived.[1] Three additional ideas linked to the fundamentals of this definition are: that poverty is a major threat to sustainability; time scale is of importance due to the unavoidable time required for land to rejuvenate; and once particular resources are exhausted with no new stocks found, alternatives must be discovered.[2]

[1] Batterham, R.J. "Ten Years of Sustainability: Where do we go from here", Research Paper

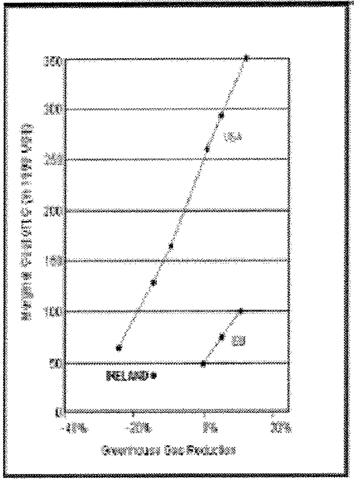
[2] Batterham, R.J. "Production of Primary Metals – Towards Improved Sustainability", European Metallurgical Conference, 16-19 September 2003.



These elements are essential and interdependent. It has been demonstrated that improvements in one element come at the expense of the other elements. There is a limit to how fast society can change; how fast financial vehicles and investments can move or how fast biodiverse systems can respond to environmental changes without significant loss.[1] Some stability in the community is required as a necessary condition to engage economic and environmental performance. This suggests trade-offs between the factors are needed.

[1] Batterham, R.J. "Chemeca Presentation", 2003.

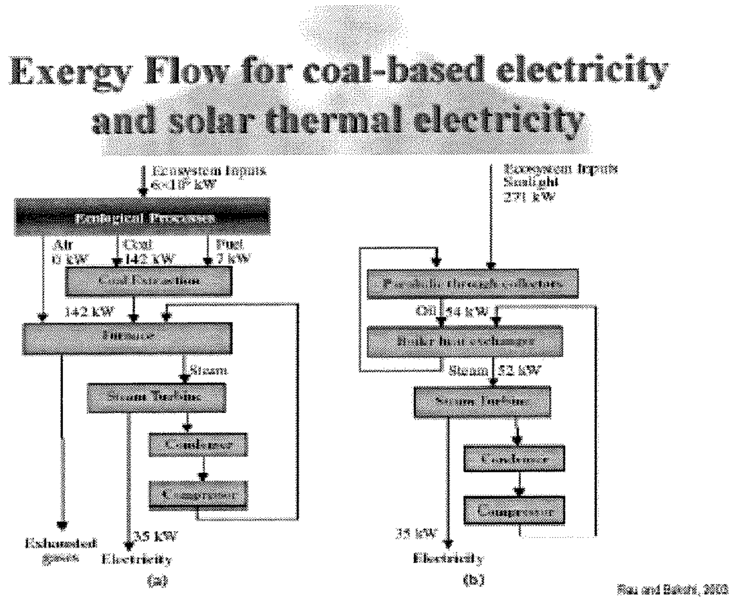
Greenhouse Gas Trade - Offs



- Cost increases with level of control i.e. Reduction of greenhouse gas emissions
- Mitigation cost is a combination of direct abatement, implementation costs and macroeconomic costs
- The USA has the greatest cost increase for small emission reductions compared to other developed nations

Mitigation reduced the sources of greenhouse gases. The costs associated with this action are direct abatement costs (engineering and technological), implementation abatement costs (associated with information, institutions fiscal devices) and indirect costs (macroeconomic effects and ancillary benefits and costs). Costs tend to increase with level of control. This example measures mitigation from bottom-up models. This model is disaggregated by sector, technology and energy. The single line on the graph represents the cost for mitigation in changing the greenhouse gas reduction (as a percentage of the total emissions).[1]

[1] Seroa da Motta, R. "Mitigation Policies and Economic Impacts", International Workshop on Climate Change Mitigation and Challenges to Chinese Economic Development, Beijing, China, 11-13 September 2002.



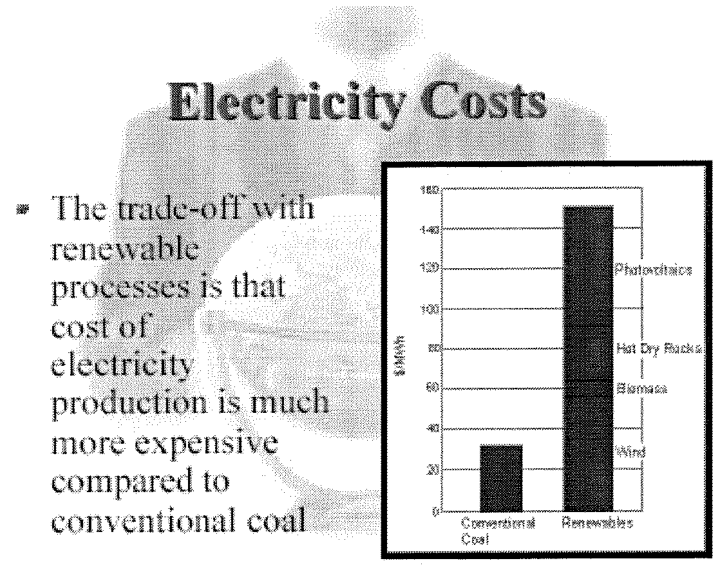
Exergy flow through industrial and ecological systems for life cycle of (a) coal-based electricity, and (b) solar thermal electricity.

Coal and fuel require ecosystems services for making them available near the earth's crust. In contrast, sunlight does not need any ecosystem services.1

Elasticity must also be considered. Denmark's high level of wind power is subsidised by standing capacity in other countries to which Denmark is connected.

But distributed power will come based on gas and hydrogen and this may make quite some difference as the waste heat can be utilised at the energy users site.

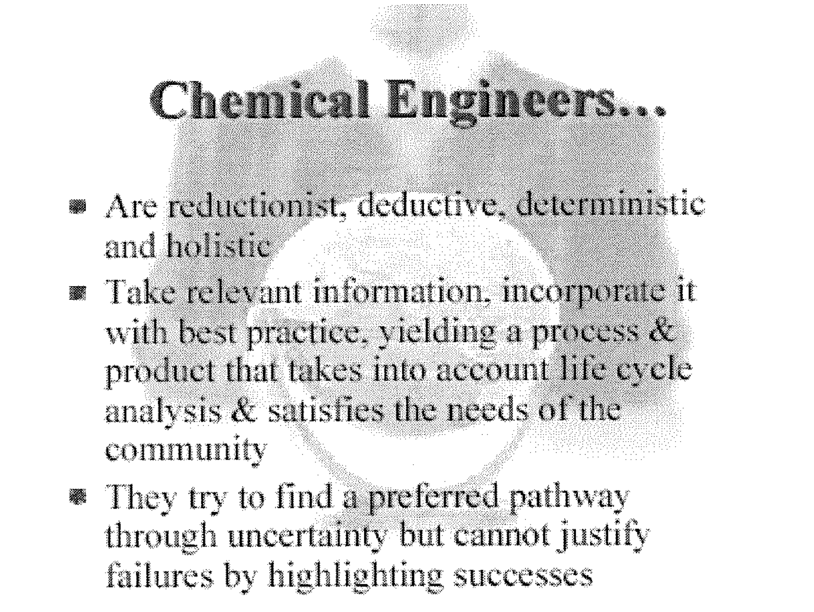
1 Bakshi and Fiksel, AIChE Journal



Slide[1]

[1] Prime Minister's Science, Engineering and Innovation Council, "Beyond Kyoto – Innovations and Adaptation", December 2002.

Many others could be included e.g. solar thermal, wave power. The realities are that sustainability arguments suggest some parallel paths, albeit with some apparent contradictions (see later).



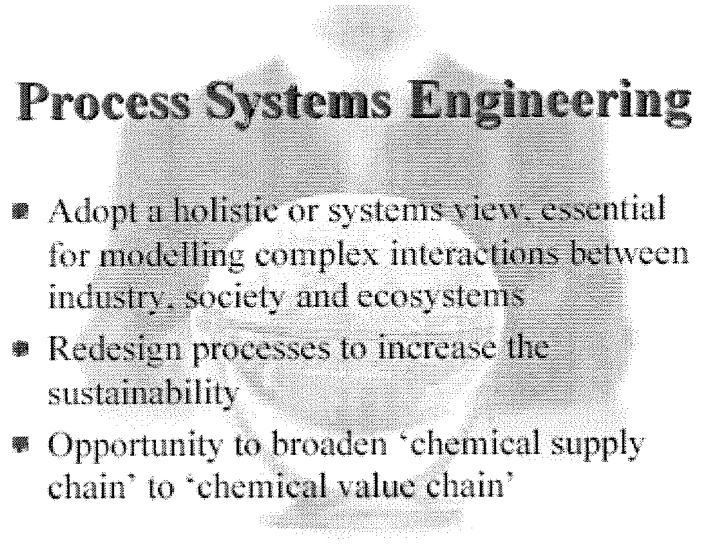
Slide[1],[2]

In the industrial age, chemical engineering has avoided the main dangers of being too specialised. In simplest terms, the actions of chemical engineers are reductionist, deductive, deterministic and holistic.[3]

[1] ibid

[2] ibid

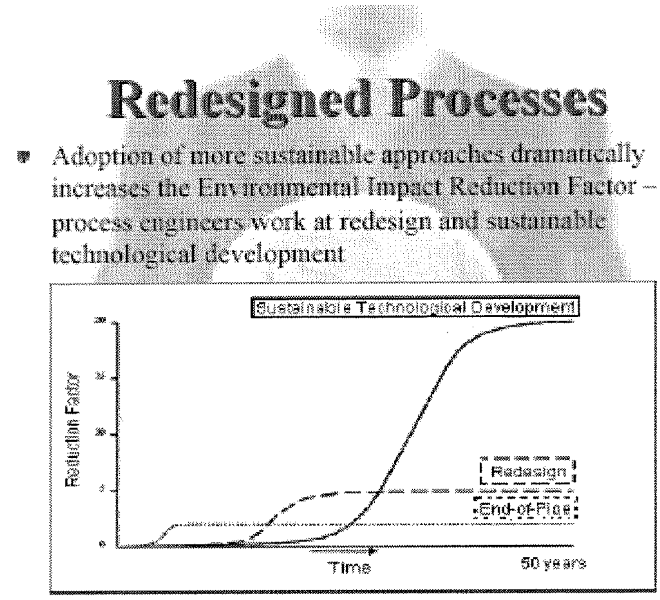
[3] Batterham, R.J. "Chemeca Presentation", 2003.



Process systems engineering demands a special mention.

Slide[1]

[1] Bakshi, B.R. & Fiksel, J. "The Quest for Sustainability: Challenges for Process Systems Engineering", AIChem Journal, Vol.49, No. 6, June 2003.



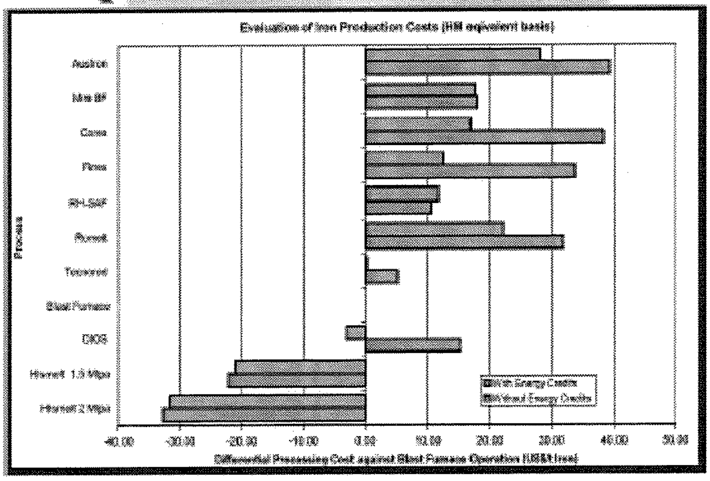
Slide[1]

By considering more issues, there is more reduction of the environmental impact. The graph represents three solutions and their power to decrease the impact of society on the environment. The end-of-pipe solution is used in all kinds of conventional industry to meet the requirements of environmental laws, but it does not result in a fundamental change in processing because it costs more material and energy than the original way of processing and it is mostly an obstruction towards long-term innovations. Recently more processes are being redesigned to cause less impact on the environment. Hence a high decrease of environmental impact needs a large and broad concept to change things fundamentally.[2] The role of process engineers is more focussed on redesigning processes and sustainable innovations.

[1] Korevaar, G., Jan Harmsen, G. & Lemkowitz, S.M. "Sustainability in Process Design Methodology", Mergers and Acquisitions, the truths, the tactics, the trends, 21st Annual European Colloquium, The Hague, April 20th, 2000.

[2] ibid

Improvements with HIsmelt

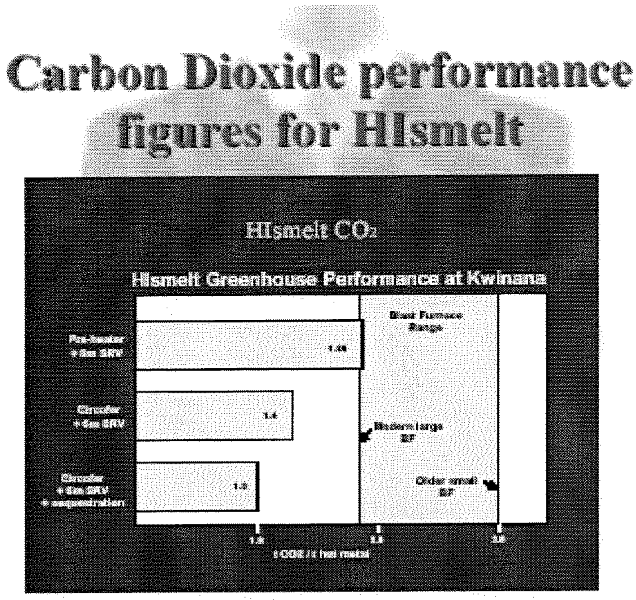


By introducing new processes, which decrease the environmental impact, there can also be a long term cost savings as demonstrated by the HIsmelt process in iron ore production.[1]

[1] HIsmelt - Meeting the High Quality Metallics Challenge
The Australian Academy of SEAISI 2001 - "Challenges for the Asian Steel Industry in the New Era", Kuala Lumpur - May 2001
T Goldsworthy and C McCarthy

Competitive advantage of HIsmelt , in terms of iron production

The Energy credits looks at the same process for different offgas qualities and therefore conversion efficiency (higher quality, higher conversion). Conversion costs were offset against electrical costs to determine power credits



Process redesign does deliver.

CASTRIP~

A Process for Twin Roll Casting of Steel Strip

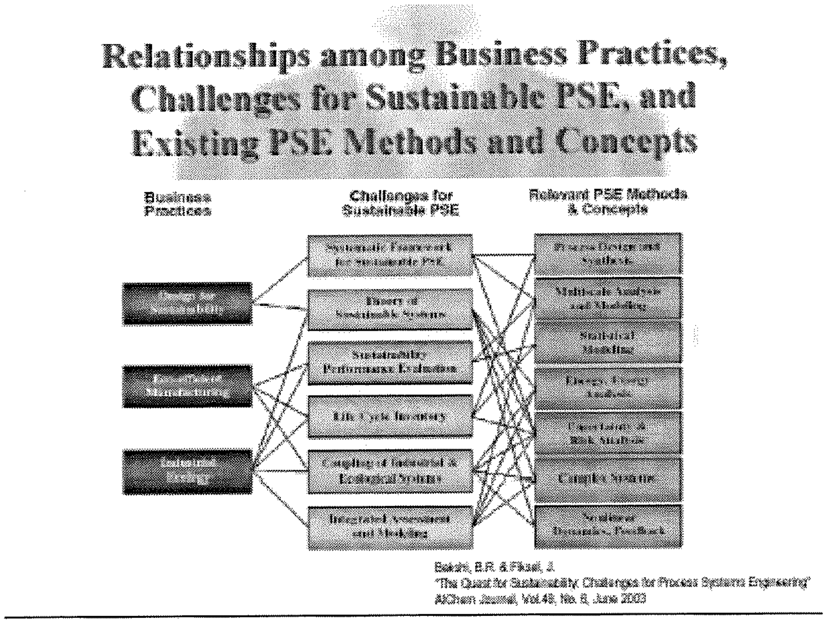
- Relative energy usage and emission by conventional casting processes and CASTRIP technology

Process	Energy Consumed (GJ/t)	GGE (t CO_2 equiv/t)*
Thick Slab Caster + Hot Strip Mill	1.8	0.2
Thin Slab Caster + Hot Strip Mill	1.08	0.14
CASTRIP process	0.2	0.04
Savings – CASTRIP vs. Thick Slab	89%	80%
Savings – CASTRIP vs. Thin Slab	81%	71%

** GGE – Greenhouse Gas Equivalent or tonnes of CO_2 equivalent per tonne of steel produced*

The construction is nearing completion and commissioning for the world's first fully commercial strip casting plant for production of thin-gauge, flat rolled steel. Its unique features include much lower energy consumption and reduced environmental emissions. It is also anticipated that the process will have a lower operating cost than the conventional processing route. This table demonstrates energy saving with CAST compared to traditional production methods.[1]

[1] Campbell, P., Blegde, W., Mahapatra, R. & Gillen, G. "The CASTRIP Process for Twin Roll Casting of Steel Strip", 2001 Electric Furnace Conference Proceedings, Iron & Steel Society.



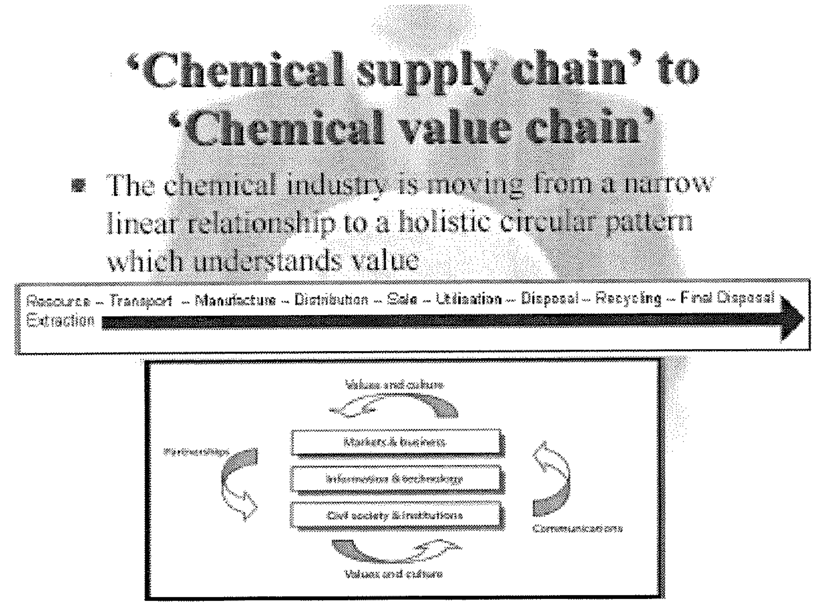
A systematic framework is essential for developing and applying scientifically rigorous tools and techniques for sustainable process system engineering. Given the complex multi-scale and multi-disciplinary nature of the task, hierarchical methods are appealing due to their ability to handle such systems in a systematic manner. (refer to the authors Bakshi and Fiksel)

Many analyses of limited use due to their unknown quality and disparate data sources that often fail to satisfy thermodynamic laws. Much remains to be done here.

Our tools, concepts, techniques have improved the viability of chemical processes and made results of PSE industrially feasible.

Now some tools expanded to develop new technologies and products that are inherently sustainable, e.g. GlaxoSmithKline reduction in inventory by 99% and in impurities by 93% by use of spinning disk reactors.

But. Life gets more complex as the analysis boundary expands to include socio-economic-ecological aspects.



Slide[1],[2]

An interesting perspective is that sustainability is not an end state that can be reached; it requires boundaries of 'the process' to be greatly expanded. Process system engineering has the opportunity to achieve this by broadening the chemical supply chain to the chemical value chain where the value chain shows the responsibility for sustainability and value lies with all those involved in the chain, not just the traditional perspective of those operating downstream in the supply chain.[3]

[1] IChemE, "Sustainable Development Progress Metrics", 2003.

[2] Science for a Sustainable Future, "ECOS", July-September 2003, pg.15.

[3] Bakshi, B.R. & Fiksel, J. "The Quest for Sustainability: Challenges for Process Systems Engineering", AIChem

Linking Sustainability to Engineering

- Sustainability & chemical engineers interests lie in considering outcomes & implications
- Sustainability is a strategic framework which builds on traditional frameworks of mass and energy balances
- Sustainable development can only be accomplished if approached in multidisciplinary way
- Should chemical engineers just accept that some processes are simply unsustainable?

The nature of chemical engineering is in using basic scientific principles to solve practical problems. In the work of chemical engineers, it is vital to always consider the outcomes and the implications. Sustainability is all about this, and therefore makes a good framework for our interactions with the community. As a strategic framework for chemical engineering, sustainability builds upon the traditional framework of mass and energy balances. At the most practical level, it offers concepts easily grasped by the classically trained engineer. Sustainability requires teamwork and a multi-disciplined approach. Strong interactions with all stakeholders is necessary.[1] One school of thought is that sustainability does not yet have an important role in the work of engineers and is based on the fundamental question 'should chemical engineers just accept that some processes are simply unsustainable?'[2]

[1] Batterham, R.J. "The Chemical Engineer and the Community", Chemical Engineering: Visions of the World, Chapter 4, Elsevier Science B.V., 2003.

[2] Sharratt, P. "Sustainable Development and Technology", Editorial – Special Issue of Process Safety and Environmental Protection, IChemE, 2003.

The Practicalities

- Use of scenarios, even with contradictory paths
- Traditional problem solving not enough, wider implications needed, well outside the boundaries of conventional processes
- Use of tools from social sciences (eg. Focus group discussions), tools from business analysis (eg. Case Studies)

Actual changes being made to practices to enhance sustainability include the use of scenarios, expansion of traditional problem solving and the use of tools from the social sciences (eg. focus group discussions) and from business analysis (eg. case studies).[1]

[1] ibid

New Issues to Confront

- Governance of technological change
- Evaluation of risk and opportunity under uncertainty
- Role of new technology in ameliorating or accentuating social and economic inequity

---

Scenarios with Contradictory Paths

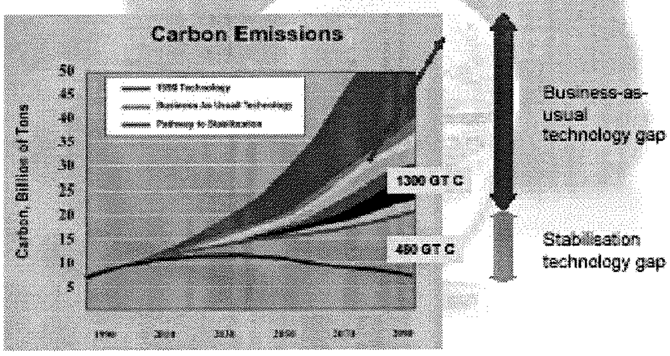
- Developing scenarios call for seemingly contradictory paths to be pursued simultaneously eg. Hydrogen from fossil fuels and the development of renewables technology are both 'right' for greenhouse gas abatement

---

Slide[1]

[1] ibid

Commitment to Stabilisation requires closing two technology gaps



Source: Battelle, 2003

The new issues chemical engineers are faced with are not their problems alone to solve and consequently the traditional beliefs that engineers solve problems has to evolve to the idea that chemical engineers provide option to solving larger issues.[1]

[1] ibid

The Future for Engineers

- Ultimately chemical engineers will provide options over problem solving
- Unique position to generate options for solutions as nature of discipline reductionist, deductive, deterministic & holistic

---

The new issues chemical engineers are faced with are not their problems alone to solve and consequently the traditional beliefs that engineers solve problems has to evolve to the idea that chemical engineers provide option to solving larger issues.[1]

[1] ibid

Existing Measurement Frameworks

- Financial
- Triple-bottom line
- Global Reporting Initiative
- IChemE's Sustainability Metrics Package

Financial Reporting – is the alignment between the interests of investors and management that makes financial disclosure powerful. It is driven by the positive and reinforcing feedback impact on shareholder value.

Triple-bottom Line Reporting – behaviour of company driven by disclosure and adherence to all areas the company affects (economic, social and environmental).

Global Reporting Initiative – concerned about indicators for measuring economic, environmental and social impact – regulatory in nature, but voluntary in exercise. It establishes a global presence and a credible guidelines-setting process for environmental reporting.[1]

[1] Batterham, R.J. "The Chemical Engineer and the Community", Chemical Engineering: Visions of the World, Chapter 4, Elsevier Science B.V., 2003.

IChemE's Sustainability Metrics

- Indicators used to measure sustainability performance of an operating unit
- Helps to set targets, develop standards for internal benchmarking & monitor progress year-on-year
- Report look at profile, summary, vision & strategies, policy & organising and performance
- Metrics presented in three groups
  - Environmental
  - Economic
  - Social Indicators

Slide[1]

[1] IChemE, "The Sustainability Metrics – Sustainable Development Progress Metrics, recommended for use in the Process Industries", http://www.IChemE.com, accessed on December 8 2003.

Sustainability Scorecard

Economic	Environmental	Societal
Direct ■ Raw material costs ■ Labour Costs ■ Capital Costs ■ Operating Costs	**Material Consumption** ■ Product & packaging mass ■ Useful product lifetime ■ Hazardous materials used ■ Eco-efficiency	**Quality of Life Cycle** ■ Breadth of product or service availability ■ Knowledge enhancement ■ Employee satisfaction
Potentially Hidden ■ Recycling revenue ■ Product disposition cost	**Energy Consumption** ■ Life cycle energy ■ Power in use operation	**Peace of Mind** ■ Perceived risk ■ Community trust
Contingent ■ Employee injury cost ■ Customer warranty cost	**Local Impact** ■ Product recyclability ■ Run-off to surface water	**Illness & Disease Reduction** ■ Illness avoided ■ Mortality reduced
Relationship ■ Customer retention ■ Business interruption due to stakeholder interventions	**Regional Impacts** ■ Smog creation ■ Acid rain precursors ■ Biodiversity reduction	**Safety Improvement** ■ Lost-time injuries ■ Reportable releases ■ Number of incidents
Externalities ■ Ecosystem productivity loss ■ Resource Depletion	**Global Impacts** ■ Global warming emissions ■ Ozone depletion	**Health & Wellness** ■ Nutritional value provided ■ Subsistence costs

Slide[1]
[1] ibid

The Scorecard utilises the Sustainable Development Principles of Economic, Social, Environmental and Governance Sphere

Looking at each sphere it then evaluates aspects relevant to the process to make appropriate decisions

Future Frameworks

- Sustainability cannot be achieved without stability between economic, environmental & social factors
- Development of a framework for rate of change tolerated between these factors will help in assuming an overall sustainable & successful position

A new field of research is ready to be explored where sustainability cannot be achieved without stability between economic, environmental and social factors. Exploration of this field could establish a framework identifying how advances in environmental factors affect the economics of the organisation and if it ultimately drives sustainability forward in the long term. This could follow on to systems showing the rate of change tolerated in any of the three prime directions to assume an overall sustainable and successful position.

Alternative approach to sustainability indicators

Step 1 – develop conceptual framework defining what is being evaluated.

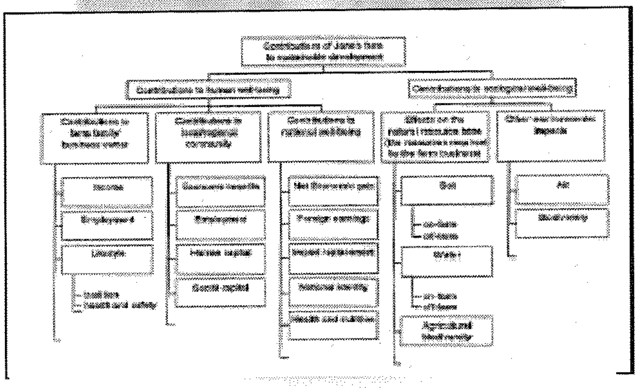
Step 2 – sub-divide the overall objective into more specific objectives until there are objectives that can be measured.

Step 3 – identify indicators that address the operational objectives.

Step 4 - aggregate indicators that lower levels to form a core set, the reporting convenience.

Bureau of Rural Sciences, Government Department of Agriculture, Fisheries and Forestry

Example of a generic component tree



Bureau of Rural Sciences,
September 2003 – Science for Decision Makers

Teaching/Accreditation

- Primary role for IChemE in enhancing sustainability
- Often in Chemical Engineering tertiary teachings Sustainable Development is an 'add-on' not a core unit
- At one university, students are only formally exposed to sustainability as a sub-topic for a subject in the first year of study
- Sustainability endorsed enthusiastically by the Institutions but the Surrey/Melbourne University surveys show student knowledge is inadequate

Conclusions

- Social pressures demand Sustainable Development
- Chemical Engineers are well placed because sustainability builds on traditional frameworks
- There are measurements for Sustainability through various systems (Metrics, Scorecard, MMSD) but more work is needed
- Teaching/Accreditation of courses where sustainability is not yet a core area

IChemE's Role

- Shift perceptions
- Subject group which focuses on sustainability at a community, industry & tertiary education level
- Role of accreditation
- Should we run an IChemE site to provide a Forum for interaction, like BBC iCan?