Forum for the Future

THE SUSTAINABILITY OF THE CHEMICAL INDUSTRY

A REPORT FOR THE CHEMICALS INNOVATION AND GROWTH TEAM: REGULATION AND REPUTATION STRATEGY DEVELOPMENT GROUP

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1 EXECUTIVE SUMMARY

The chemical industry is an important engine of wealth creation. Its products are often key to the way in which human society meets its needs and can offer solutions to other sectors of industry in their pursuit of sustainable development, such as the energy and waste disposal sectors. However, the overall public perception of the industry continues to decline. Committing itself to true sustainability offers the industry a number of opportunities, not least to improve the acceptability of its activities by the general public.

One of the headline areas for discussion within the CIGT is sustainability, and this report aims to establish the degree to which it is possible to conceptualise a sustainable chemical industry. The report also attempts to determine a baseline of sustainability performance within the industry and to highlight examples of best practice within individual chemical businesses around the globe.

A literature review and engagement with key stakeholders were key elements of the research methodology and enabled the elements of a sustainable chemical industry to be plotted within a "Sustainability Matrix". This matrix was designed in line with Forum for the Future's five capitals model and analyses the potential contribution of the industry both as a business entity, a provider of products and services and finally as a significant member of the community.

A number of common themes in relation to the achievement of sustainability within the industry arose out of the research and interviews that were conducted. These included the need to move away from non-renewable, hydrocarbon feedstocks and energy sources, the potential for pollutant dispersal during product use and at end-of-life disposal, and the need for the promotion of sustainable development as a concept throughout the industry and throughout the whole value chain.

The sustainability matrix acts to highlight issues for consideration and suggest a number of actions that may contribute to the overall sustainability of the industry. The headline features of the matrix include the following:

1. **The use of renewable and recycled raw materials**
   Using scarce or depleting resources means that the industry is vulnerable to price fluctuations and ultimately lacks security of supply in the long-term. Sustainability will require the industry to use significantly less petroleum based raw materials in the productions process and to actively seek to use more sustainable alternatives.

2. **The use of renewable energy**
Currently our society relies heavily on a finite supply or fossil based fuels, which places six billion tonnes of carbon emissions into the atmosphere every year when burnt, making a significant contribution to global climate change. Given that the current rate of CO_2 emissions into the atmosphere is unsustainable, the chemical industry, along with other sectors, will have to increase the total amount of renewable energy it uses throughout its operations.

3. **The total environmental impact for both products and processes**
Sustainability will require that the negative environmental impact of both products and processes are eliminated, or at least significantly reduced. Some of these impacts will be associated with energy use and raw materials (discussed above) but will extend to include a range of issues such as water consumption and waste production.

4. **The health and safety risk to employees and society through the products made available.**
A number of properties within certain chemicals cause concern in relation to the possible negative health effects associated with their handling by employees and to the end user throughout the lifecycle of a product in which they are found. The industry will have to reduce and eliminate, wherever possible, the potential risk to human health associated with its products and processes.

5. **The education and skills of present and future employees, contractors and suppliers necessary to deliver sustainable development within the industry**
Delivering sustainability within the industry will require that everyone involved understands his or her individual responsibilities in achieving more sustainable development. This will require that employees, whether present or future, have the appropriate competencies to make and implement decisions that encourage more sustainable development.

6. **Engagement in the debate with the public and regulators**
The industry should support the societal process of sustainable development i.e. the industry's actions should not subvert but support the intention or meaning of legislation designed to foster more sustainable development.

7. **The delivery of economic performance**
Good economic performance is essential to ensure that the industry is attractive to investors in a competitive environment, albeit with increasing emphasis on the importance of environmental and social performance of business and industry more widely.

These elements should form the basis of any vision of a sustainable chemical industry. However, it is important to consider the views of other stakeholders in determining a vision and strategic plan of action to ensure greater transparency and improve accountability.

The chemical industry has already made a number of performance improvements in relation to environmental impacts, notably in the areas of energy efficiency and waste management. Many of these improvements have been made as a direct result of the Responsible Care programme.

However, the Responsible Care initiative in itself has not been specifically designed as a vehicle to promote or communicate a strategic vision and approach to sustainable development. In essence, Responsible Care is a tool that can be used to manage incremental improvements in environmental protection, product stewardship and occupational health and safety. To fully address the philosophy of sustainability and the operational implications of progress towards this vision would require significant changes to Responsible Care.

The key challenge will be for the industry to think about systemic change at the highest level and to recognise that sustainability will require more significant action than minimising the negative impact of current products and processes. It will require the industry to be creative and innovative in its approach to ensure that the solutions it delivers integrate fully the needs of the economy, society and the environment.

2 INTRODUCTION

The Chemicals Innovation and Growth Team (CIGT), located within the UK Government's Department of Trade and Industry (DTI), has been designed to stimulate the growth and sustainability of a competitive chemicals industry in the UK and to embrace the views of a range of stakeholders. The work of the CIGT will review the factors affecting the future competitiveness and sustainability of the UK chemicals industry. The expected output will be a series of concrete actions designed to both remove constraints and to promote innovation and growth of the industry.

The CIGT proposes that the overall health of the chemical industry is linked to its competitiveness and sustainability. In ensuring that the work of the Regulation & Reputation Strategy Group - and the CIGT more generally - promotes greater sustainability it is important to establish a more complete and robust definition of the sustainability framework for the industry and the key sustainability challenges to achieving more sustainable development.

In taking forward this initiative, the CIGT has established an Advisory Board of various external stakeholders, which has endorsed four focus areas; Customers & Markets, Reputation & Regulation, Innovation & Technology Pull Through, and Skills & Competencies. Strategy Development Groups have been established to consider each of these four areas.

Having established the overall vision of sustainability for the industry it will be important to establish a clear overview of existing as well as emerging initiatives and practices that contribute to the sustainability of individual businesses or the industry as a whole. The role of this final report will be to bring together examples of the most recent developments within the industry in the sustainability arena, and to highlight the linkages to the work of the CIGT.

2.1 FORUM FOR THE FUTURE'S ROLE

Forum for the Future is a leading sustainable development charity that works with key decision-makers in business, government and higher education to accelerate the building of a sustainable way of life.

The Core Programmes within the Forum provide a complete and integrated solution to sustainability issues in the sectors outlined above. By pursuing partnerships with key organisations, the Forum has developed several cutting-edge initiatives that are pushing forward the sustainability agenda. As a charity, we communicate this pioneering work to a wide range of opinion-formers and decision-makers in UK society and beyond.

Forum for the Future believes that the business community has a leading role to play in helping deliver sustainable development across society. We seek to transform corporate thinking and behaviour such that sustainability principles become an integral part of business strategy and practice. We achieve this through a mixture of challenging advisory work, capacity building, awareness-raising and information sharing with networks of partner companies, as well as issues-based project and policy work that helps push forward the sustainability agenda.

The incorporation of sustainable development principles into the future strategic direction of the chemical industry is a critical way in which the business community and society more generally can begin to move towards sustainability.

2.2 REPORT SCOPE

The headline areas for discussion within the CIGT are:

- Competitiveness and;
- Sustainability;

This report focuses on the second of these areas. It should be noted that while the overall competitiveness of the industry may be linked to its sustainability, issues linked to competition are not addressed specifically within this report.

The final report will examine the following three key areas:

1. The sustainability of the chemical industry.

   Is it possible to conceptualise and describe a "genuinely sustainable chemicals industry"? This section examines the scientific basis of sustainability to determine the elements necessary for the development of a sustainable industry. In addition, the report will also examine the physical structure of the industry and analyse whether it is possible to develop a country-specific model of a sustainable chemicals industry.

2. Current practice and initiatives.

   Having attempted to define a genuinely sustainable chemicals industry this section will examine existing examples of good practice within the industry and attempt to benchmark individual company initiatives. The study will focus specifically on a number of key elements including innovation, manufacturing, environmental and supply chain management, stakeholder relations and community engagement, and communications.

3. Implications and recommendations

   What are the implications of the research for existing initiatives with the industry and in helping develop recommendations from the CIGT as regards the future health of the sector.

Much of the information presented in this report relates to the chemical industry in the UK. However, the way in which the largest chemical companies are structured and the unique structure of the sector itself, means that at times this distinction is somewhat artificial. Thus parts of the discussion and some of the themes highlighted will be equally applicable to chemical companies operating outside the UK.

This report has been written specifically for the CIGT's Reputation & Regulation Group, which is tasked with clarifying the issues in this area and with making recommendations for improvements to existing approaches and, where appropriate, for more radical change. The Group will also be responsible for identifying actions required by the industry and Government to improve the current reputation of the UK chemicals industry.

2.3 RESEARCH METHODOLOGY

The information contained within this report is drawn from two principal lines of inquiry. The first is a detailed literature review with a primary objective to gather publicly available information from a range of sources related to existing practice and the key sustainability issues facing the industry.

This literature review examined the websites and published materials available from companies, industry associations, academics and other organisations already identified by the CIGT as key stakeholders.

The second main source of information came from semi-structured interviews with a number of key individuals working in the chemical industry. These interviews were mainly conducted by telephone, although some were carried out on a face-to-face basis.

The information collected from interviews was subjected to analysis and supplemented through a process of dialogue with a number of industry representatives. The following companies were either interviewed or contributed to this report through a workshop held on Wednesday 10th July:

- BASF
- Contract Chemicals
- ICI
- Norsk Hydro
- Robinson Brothers
- S C Johnson
- Shell

Interviewees were asked to identify key sustainability concerns within their own operations and within the industry more widely, and to describe the elements essential to achieving sustainability within the sector using the Forum's sustainability matrix.

Information from the interviews supported the literature review, as participants were encouraged to identify examples of existing good practice and to comment on the opportunities and constraints presented by current initiatives.

2.3.1 The Sustainability Matrix

Central to the development of the Forum's work with a range of our partners, is the practice of envisioning a specific organisation's contribution to the creation of a sustainable future. One of the tools that can be used to explore the potential practical contribution of an organisation to sustainable development is the "sustainability matrix".

The matrix plots the five capitals (see below) against the three ways in which an organisation can be considered to "manifest" itself - as a business, as a provider of products and services and finally as a significant member of the wider community. As such, the matrix acts as a framework across which an organisation's contribution to sustainability can be mapped. By reviewing current practice against the possible contributions and by examining the contributions, collectively within the matrix, it is possible to gain insights into where an organisation can and does contribute to sustainability.

	As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
NATURAL			
HUMAN			
SOCIAL			
MANUFACTURED			
FINANCIAL			

2.3.2 The Five Capitals Model

Forum for the Future considers that sustainability may best be defined as the 'capacity for continuance into the long term future'. Put simply, anything that can go on being done on an indefinite basis is sustainable. This is distinctly different from sustainable development, which is the process by which we move towards sustainability. It is a dynamic process through which organisations (and society more widely) can begin to achieve a balance between the environmental, social and economic aspects of its activities.

A useful way of understanding sustainability is in terms of the economic concepts of capital and income. Sustainability depends upon maintaining, and where possible, increasing stocks of certain capital assets, so that we can succeed in living off the income without depleting the capital. There are five types of capital, which our economy and each and every organisation needs in order to function properly.

Natural capital (also referred to as environmental or ecological capital) is any stock or flow of energy and matter that yields valuable goods and services. It includes resources, some of which are renewable (timber, grain, fish and water), whilst others are not (fossil fuels); sinks which absorb, neutralise or recycle wastes (for example forests sequestrating carbon dioxide); and processes, such as climate regulation. Natural capital is the basis not only of production but of life itself.

Human capital consists of people's health, knowledge, skills and motivation, all of which are required for productive work. Enhancing human capital (for instance, through investment in education and training) is central to a flourishing economy.

Social Capital is all the different co-operative systems and organisational frameworks people use to live and work together, such as families, communities, governments, businesses, schools, trade unions, voluntary groups. Although they involve different types of relationships and organisation they are all structures or institutions that add value to human capital, and tend to be successful in doing so if based on mutual trust and shared purpose.

Manufactured capital comprises material goods, or fixed assets – tools, machines, buildings, and other forms of infrastructure - which contribute to the production process, but do not become embodied in its output.

Financial capital plays an important role in our economy, by reflecting the productive power of the other types of capital, and enabling them to be owned and traded. However, unlike the other types, it has no intrinsic value; whether in shares, bonds or banknotes, its value is purely representative of natural, human, social or manufactured capital.

In reality, the five 'capitals' actually represent *all* the resources available to a society – or to any economic unit of that society – for achieving sustainability. In economic parlance, each form of capital is represented by stocks, in which we may or may not invest, and from which we expect a range of benefits to flow. It can be argued that most if not all of our current environmental and social problems may be explained by the imbalance of investment across different types of capital stock.

To operate within a sustainable framework, industry should be maintaining and where possible increasing the stocks of all five capital assets, in order to live off the income that the capital provides, rather than liquidating capital assets for current consumption. Current patterns of production and consumption are unsustainably liquidating and depleting natural capital.

It should be noted that a number of other models of sustainable development are currently in use. The most popular ways of expressing sustainable development in a business context is through the use of the triple bottom line. While this is a useful analogy and provides an easy way to think about some of the elements that need to be considered in sustainable development, Forum for the Future prefers to use the 5 capitals framework to assess the contribution individual business or industries could make towards sustainability.

2.4 STRUCTURE

The rest of this report is divided into the following sections:

Section 3 provides a broad overview of the chemical industry, describing recent developments within the industry as well as the need to think strategically about the plotting a course for its future development that incorporates sustainability.

Section 4 presents the results of the Forum's initial research. This section incorporates the findings from both interviews and published materials into the "Sustainability Matrix" and provides some analysis of what sustainability will require of the industry.

Section 5: This section examines the current performance of the chemical industry against a number of indicators and highlights a number of examples of best practice from within the industry.

Section 6: Sets out a range of conclusions and suggests key areas for consideration in taking forwards the work of the CIGT.

3 THE CHEMICAL INDUSTRY

The global chemical industry has changed substantially in the last two decades as the "traditional" companies have de-merged and divested business units while others have concentrated their activities through various mergers. This has encouraged the entrance of new companies into the market and in some cases these new businesses have formed novel affiliations under new names and brands.

The following section examines the broad divisions within the industry and examines the need for the industry to adopt a systematic approach to sustainability.

3.1 STRUCTURE OF THE INDUSTRY

The chemical industry manufactures a diverse range of materials and products, as such there is no one typical product or one typical company that describes the industry in its entirety. In fact, the diversity of the chemical industry's products and services is such that they can be found in all areas of our modern lives.

The diverse nature of the industry has often led it to be described as three distinctly different, yet interdependent, types of businesses that together make up the chemical industry:

The commodity or "bulk" chemical segment creates an enormous range of specific chemicals from a variety of natural raw materials including oil, coal, gas, air, water and minerals. About half of the chemical materials and products made by the bulk industry are purchased directly by other industries as intermediates and are vital inputs for the products and services that they provide.

The remaining materials are used by other "specialist" or fine chemical companies for the synthesis of intermediate compounds and "effect" chemicals that are used in the production of a whole range of products. These products include - but are not limited to - fertilisers and crop protection chemicals; paints, coatings and solvents; food additives and preservatives; flavours, fragrances and cosmetics; soaps and detergents; dyes, pigments and inks; building and insulation materials; electronics chemicals; synthetic fuels and additives; synthetic rubbers, adhesives and waxes.

In general, a commodity or bulk chemical is available from multiple sources to a standardised specification and is bought on specification and price, while specialised or fine chemicals have a much higher price per unit and are not so widely available. An "effect chemical" is specified for what it does, not what it is. For example, in the cosmetic sector chemicals are sold as emollients (the effect they have) not by chemical formula.

Some of the main purchasers of products created by the specialist chemical segment, and the third essential element of the chemical industry more generally, are the pharmaceutical companies and health care businesses.

It is important to recognise that this structure may mean that there are many stages between the sale of the chemical and the final consumer product, and different segments of the industry will share many of the same customers. For example, a car manufacturer will procure products and services such as rubber and electronics, whose creation will have been reliant on other chemical inputs in addition to the direct purchase of bulk chemicals for use in the production process.

The types of companies operating within each of these segments vary almost as much as the products that they produce. Some chemical companies are ranked amongst the largest companies in the world, employ many thousands of workers and have multiple manufacturing sites located throughout the world. Other chemical companies may make a few products at one site and are relatively small in size.

Historically, chemical companies have either integrated bulk, specialty and pharmaceutical operations, or else clustered together to act as an integrated unit of separate companies. However, in today's market there are a few examples of truly integrated chemical companies and the general trend continues to be away from large integrated, centralized production towards smaller, more disparate and specialised operations.

3.2 SUSTAINABLE DEVELOPMENT AS AN OPPORTUNITY

In the last decade, a number of initiatives within the chemical industry have led to the development of "greener" chemicals, technologies and processes. In addition, individual businesses, by putting better management processes in place, have seen improvements in safety, energy and process efficiency. These have been matched with some equally impressive reductions in waste and costs.

In that time however, the public's acceptance of the industry has continued to decline. For example, the results of this year's Pan European Survey assessing the image of the chemical industry[1] show that despite higher ratings for pollution control efforts and a growing recognition of the general importance of the industry, the perception of the industry's environmental and social performance is still declining.

The public's concerns about the potential damaging effects of chemicals can, at least in part, be traced back to the publication of Rachel Carson's book *Silent Spring*, which illustrated how man-made chemicals could devastate the natural environment. In the following years the industry was further marred by a number of high profile incidents of poor safety and environmental performance. In combination, these events have led society to place increasing pressure on the industry to improve its environmental and social performance. In the absence of drastic change it is likely that the public's overall trust in the industry will continue to remain low and calls for greater regulatory controls can be expected to increase.

It must therefore follow that lack of action presents a significant risk to the industry's continued license to operate. This represent a serious challenge for the industry itself.

[1] Over 9,000 citizens were surveyed by CEFIC in the period from January to mid - March 2002 in order to track the public image of the chemical industry across Europe.

It also represents a serious challenge for advocates of an accelerated transition to a more sustainable society. The benefits that we all derive from the chemical industry are only grudgingly referred to by environmental campaigners, but they are enormous. What's more, the chemical industry (in terms of its products, processes and capacity for innovation and 'breakthrough solutions') is in fact central to the pursuit of a sustainable society; without it, the prospects of meeting the needs of nine billion people by the middle of this century are zero.

With concerted action to integrate and improve the environmental and social performance into its products and processes, and by improving accountability to all its stakeholders, the framework of sustainable development offers a unique opportunity for the industry to begin to regain the public's trust in its operations.

The path of sustainable development is forward looking; it does not suggest that we should return to a pre-industrial period. However, the path to sustainability will provide industry and society with a range of challenges. The key challenge for the chemical industry will be to actively seek opportunities for designing and developing products that create high value and long-term financial viability, meet customer needs and improve the quality of life, and to produce them in ways which protect the natural environment. It is clear that if the industry is to meet this challenge it will have to be visionary, strategic and committed to action.

4 CONCEPTUALISING A SUSTAINABLE INDUSTRY

The following section provides an analysis of the defining characteristics of a sustainable chemical industry. A number of the elements discussed are based on the outputs of the workshop and interviews with representatives from the industry. However, it should be noted that the elements discussed are not limited to these outcomes and include other key areas identified during the research phase of the project.

It must also be stressed that what is being elaborated here is 'template' as a way of dispelling confusion about what sustainability really means. It describes the characteristics that the industry would need to demonstrate in due course for it to be operating in a genuinely sustainable fashion. The period of time required to reach that point is not discussed here, but "as fast as is practically possible" provides a good rule of thumb. There remain widely divergent views on what that actually means, with some NGOs assuming it can be done in a couple of years, and some industry representatives assuming it will take many decades

What really matters is getting a better understanding of the destination (a sustainable chemical industry operating in a genuinely sustainable society) as this is to all extents and purposes <u>non-negotiable</u>. No species can continue to live unsustainably within the Earth's biophysical constraints. But the speed with which we eventually get there is almost infinitely negotiable!

This section goes on to examine the success and limitations of existing initiatives within the chemical industry. Specific reference is made to the Responsible Care (RC) programme and, where relevant, areas for improvement are highlighted.

4.1 PRESENTATION OF RESULTS

As described in section 2.3.1, the “sustainability matrix” is one way an organisation can begin to understand the concept of sustainability and examine the potential operational implications of sustainable development.

The approach applied to the sustainability matrix for the purpose of this study has addressed the sustainability of the whole chemical industry rather than the activities of a specific organisation. The matrix has also been used to provide a brief rationale of how each component identified would make a contribution to sustainable development. However, it does not discuss in specific detail the initiatives that have been - or could be - adopted either by the industry or individual businesses as these are discussed in more detail in subsequent areas of the report.

4.2 COMMON THEMES

Several of the interviewees discussed similar themes in relation to the achievement of sustainability within the industry. These themes are summarised in the following section for completeness.

4.2.1 Feedstocks

The industry uses more petrochemicals as chemical feedstocks than as the fuel for all of the industry's various production processes. The main routes to sustainability would be through the development of alternative feedstocks that do not depend on extraction of fossil fuel resources and to increasingly recycle the industry's products after their use.

The need to move away from non-renewable, hydrocarbon feedstocks is both a significant environmental and business issue. Using scarce or depleting resources means that the industry is vulnerable to price fluctuations and ultimately lacks security of supply in the long-term. As such, basing the production of hundreds of products that play a significant role in sustaining economic and social stability on limited and environmentally destructive feedstocks is clearly unsustainable.

Sustainable alternatives could be cost effective and offer security of supply, and currently there is significant work being undertaken to explore the use of waste streams, agricultural feedstocks and biotechnology. However, in considering alternative feedstocks it will be important to assess all the potential areas for impact and whether a particular substitution really represents a movement towards sustainability.

The use of agricultural feedstocks, for example, could negatively impact upon natural and social systems by encouraging increased land-take and forest clearance, reduced biodiversity through the promotion of industrial monoculture, and increasing pollution of water resources caused by fertiliser and pesticide run-off.

Other commentators suggest that biotechnology has the potential to create a range of precursor molecules, thereby reducing or eliminating the need for conventional feedstocks. However, a number of questions in relation to the use of biotechnology remain unresolved and public opinion suggests that there is currently a lack of acceptance of the technology. Therefore, any decision to expand the use of biotechnology within the industry should be based on sound science, and take both the full risk profile of the specific technology and stakeholder opinion into account.

4.2.2 Energy

The manufacturing process along with the transport of feedstocks, products and waste consumes considerable amounts of fossil fuel based energy. Therefore, the most significant environmental impact associated with the industry's energy use is its contribution to global climate change through the production of carbon dioxide and other greenhouse gases.

The industry has made considerable improvements in energy efficiency over the last decade and further improvements in this area will be important for the sustainability of the industry. However, there are clear limits to the "efficiency" strategy. The extent to which the chemicals sector develops a strategic approach to reduce the overall effect of its activities on the global climate by systematically replacing the use of fossil fuels with sustainable, renewable alternatives will be a key component of a sustainable industry.

4.2.3 Toxicity

There is continued concern over the toxicity profile of certain chemicals and chemical compounds. Persistent Organic Pollutants (POPs) such as dioxins, PCBs and pesticides are of the cause of considerable concern. They can travel considerable distances in air and water currents, tend not to degrade naturally in the environment, and can accumulate in human and other animal tissues (a process known as bio-accumulation).

The second group of chemicals that have been highlighted by a range of NGOs are endocrine disruptors. These chemicals block, mimic or otherwise prevent the normal function of naturally occurring hormones in the body.

The full implications of such chemical releases into the natural environment are unknown, although it is thought that there are a number of risks both to global biological diversity and to the overall health of the human population.

4.2.4 Heavy Metals

Some of the chemical industry's processes result in the emission of heavy metals into the natural environment. While heavy metals continue to be reduced through various initiatives at the business and industry level, an area of particular concern is the potential for their dispersal during product use and end-of-life.

4.2.5 Education

Sustainable development depends on a greater understanding of natural, social and economic systems, including how they work and how they constrain or enable certain activities.

A complete understanding of sustainability has yet to percolate throughout the industry. If the industry is to be truly sustainable it will be increasingly important for everyone involved in its success to understand the industry's purpose and commitment to sustainable development.

The education challenge extends beyond the industry's current employees and contractors to encompass future employees. As such the chemical industry has an important role to play in ensuring that society understands the requirements of sustainable development and are equipped with the information necessary to make informed choices.

4.2.6 Value Chain

Customers and the supply chain are considered a significant barrier to the adoption of more sustainable practices within the industry. If the supply chain and customers demand cheaper, rather than more effective products, any improved sustainability performance that passes cost on to the customer is unlikely to result in the successful uptake of the product and will ultimately effect the financial stability of the business.

For example, 80% of the market for fabric softner contains products that are highly biodegradable. However, due to cost considerations there is currently a drift back to less biodegradable, but cheaper, components. This suggests that there is a need for the true cost of production to be reflected throughout the supply chain.

Furthermore, bulk chemicals tend to be traded as commodities, sold on price and quality and not on the process by which they were produced. Therefore, as long as a specific product meets the quality standard and the price is acceptable to the market, it will be openly traded. In an increasingly international market progress towards sustainability this is likely to require the creation of a “level playing field” related to approved production processes and standards.

The chemical industry, in association with government, is beginning to examine pricing structures, such as differential tax rates, to reflect the sustainability of different products and this work should continue. However, in the absence of price incentives, significant change will be driven by the development of procurement policies that encourage buyers to differentiate between products based on a range of performance criteria. The Government’s own procurement policy must be directed in such a way to establish a larger market for more sustainable chemical products.

4.2.7 Stakeholder dialogue

The Responsible Care Communication Code in many countries calls for extensive candid community outreach, supply of information and integration of company emergency plans with local emergency plans. This code, built into all national programmes, requires each member-company to have ongoing processes to identify and respond to community concerns, inform the community of risks associated with company operations and the decommissioning of old units.

However, stakeholder dialogue should be concerned not only with local community advisor panels, which continue to develop around many chemical company sites, but should extend to encompass all major decision-making processes within individual businesses and the industry in general. This will require that the industry begin to be more proactive in identifying and initiating dialogue with a range of interest groups including a number of its critics.

4.3 THE SUSTAINABILITY MATRIX

The following section builds on the common themes presented above, highlighting a number of key elements for consideration when developing the chemical industry's approach to sustainability. These elements are presented against the Forum's five capitals and in reference to the main ways in which the industry can be considered to manifest itself (see section 2.3 for a full explanation of the matrix and the five capitals model).

What can the chemical industry do to maintain or enhance the 'stock' of the following resources, or 'capitals'	**As a business, accountable to shareholders**	**As a provider of products and services**	**As a significant member of the community where it operates**
NATURAL The resources and services provided by natural world	• Eliminate the use of non-renewable energy • Use energy efficiently • Use water efficiently • Use raw materials efficiently • Audit supply chain performance • Eliminate waste • Operate to a consistently high global standard of environmental and social performance • Increase resource productivity	• Develop products that reduce energy use of customers • Develop products that copy natural processes • Improve biodegradability • Remove toxicity • Eliminate persistent compounds • Design products for reuse and recycling • Service models replace products	• Protect and enhance biodiversity • Commit to long-term carbon neutrality • Eliminate noise and odour • Eliminate visual intrusion • Eliminate negative impacts of local air quality
HUMAN The energy, motivation, capacity for relationships, and intelligence of individuals	• Implement (continuous) employee training and development schemes • Develop leadership • Implement diversity and inclusiveness programmes • Protect health and safety of employees • Provide opportunities for personal growth	• Eliminate negative health and safety impacts of products • Design products that meet human needs and enhance quality of life	• Foster local employment • Develop employee volunteering programmes • Engage in dialogue • Protect human rights
SOCIAL The social groupings that add value to individuals (e.g. families, communities, parliaments, universities)	• Encourage local procurement • Ensure that employees understand company vision, policies and programmes. • Support and encourage progressive regulation	• Communicate information related to product performance, risks and appropriate use. • Assist consumers to understand the impact of their actions and consumption patterns.	• Sustainability performance is openly and accurately communicated • Develop partnerships with the local community • Involved in education programmes • Community investment programme aligned to sustainable development

MANUFACTURED The "stuff" that already in terms of infrastructure n terms of the tools, machines, roads, buildings in which we live and work, and so on.	• Maximise process efficiency • Reduce volumes of throughput (energy, raw materials etc) for each unit of output) • Audit supply chain performance	• Infrastructure encourages product reuse and recycling	• Provide communities with appropriate access to and use of physical assets. For example, community groups provided with use of office space etc outside of normal working hours. • Continued investment in the maintenance and development of infrastructure that reduces risk of negative impact on the community.
FINANCIAL The money, stocks etc. that enable us to put a value on, and buy and sell, the above resources and ways that value can more accurately represent the real 'cost' of using them.	• Makes acceptable financial returns • Account for total cost of activities encompassing both intangibles, risk and externalities • Shift the focus of management compensation from short term financial performance to include areas of sustainability performance	• Total cost accounting is reflected along value chain • Create economically viable products • Research and development priorities aligned to sustainability objectives	• Contribute to local economies through appropriate taxation in all areas of operation. • Eliminate corruption • Philanthropy aligned to strategic vision of company • Systematically avoid any "legacy effects" associated with operations and products

4.3.1 Natural Capital

THREE WAYS IN WHICH THE CHEMICAL INDUSTRY 'MANIFESTS' ITSELF		
As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
• Eliminate the use of non-renewable energy • Use energy efficiently • Use water efficiently • Use raw materials efficiently • Audit supply chain performance • Eliminate waste • Operate to a consistently high global standard of environmental and social performance • Increase resource productivity	• Develop products that reduce energy use of customers • Develop products that copy natural processes • Improve biodegradability • Remove toxicity • Eliminate persistent compounds • Design products for reuse and recycling • Service models replace products	• Protect and enhance biodiversity • Commit to long-term carbon neutrality • Eliminate noise and odour • Eliminate visual intrusion • Eliminate negative impacts of local air quality

When examining the first box in the table, we can see that this particular part of the sustainability profile of the industry is, to some degree, concerned with the environmental footprint of the industry's physical assets and activities. It represents many of the key ingredients in conventional approaches to environmental management such as reduced raw material use, energy consumption, waste and emissions.

The focus by industry on efficiency has a number of financial implications and provides the opportunity for early "win-win" solutions. Certainly, the adoption of such approaches has successfully reduced the environmental burden of some activities and simultaneously reduced costs in some companies.

Such "eco-efficiency" programmes are certainly an important contribution to sustainable development. However, they alone will not assure the environmental sustainability of the chemical industry. After all, efficiency programmes work within the same framework responsible for the problem in the first place and serve only to slow the rate of impact on the natural system. Environmental sustainability will require the industry to redesign itself in such a way as to eliminate (or at least dramatically reduce) the use of fossil fuel resources and prevent the introduction of hazardous materials into the air, water and soil at a rate beyond which natural remediation can occur.

Cost reduction programme have not been based solely on process efficiency and waste reduction, although they are essential components, but also include product reformulation. The stewardship and extended responsibility for products will play an important role in assuring the sustainability of the industry. Clearly, the products of the chemical industry can contribute to sustainable development both directly through the reduction and eventual elimination of toxicity and persistence, along with improved biodegradability, and indirectly through the contribution that individual products make to the achievement of sustainability in other industries. For example, the production of surfactants that allow fabric detergents to work at low or ambient temperature, reducing the overall energy input necessary in the cleaning process.

The toxicity profile of products is particularly important if the toxic elements are not fully consumed in the production process as incomplete consumption results in the diffuse distribution of the element within the natural environment. For example, the formaldehyde used in the curative process and the bonding of wallboards has been shown to off-gas throughout the product's life, reducing local air quality and creating a number of negative health effects. Where the material is fully consumed it remains stable within the structure of the product and the biggest risk is borne in relation to the transport and storage of the chemical.

Resource productivity is an area of growing interest in both the policy and business agenda, as there are clear attractions in finding new ways of 'getting more from less'. However, the economic benefits of using resources both more effectively and efficiently have often outweighed the need to express such desires in terms of the overall sustainability of natural and social systems. This approach has, to some extent, prevented us from understanding the inherent challenges related to sustainable resource use such as the need to understand the link between waste on the one hand and resources on the other. Clearly, the sustainable future of the industry will rely on a significant shift away from linear models of production and disposal towards greater reuse and recycling and the eventual establishment of truly cyclical models of resource use.

Another important concept for consideration under the improvement of natural capital, and related to the effective use of resources, is that of service innovation. This is based on the idea that our current product-based economies will need to shift towards more functional models, based on the provision of services in the form of performance or solutions to meet customer needs. There are already a number of examples from within industry of such models. The most quoted examples include Xerox's strategy of leasing, rather than selling, photocopiers, and Interface Inc's *Evergreen Lease* that involves the company retaining the management of the flooring solution provided, throughout its life and for its disposal.

Finally, the industry must consider the socio-environmental impacts of its operations. Most obviously this concerns emissions that are placed into the local community and nuisances such as noise and odour. However, this particular element of the matrix is also concerned with issues such as the siting and aesthetics of new developments, along with wider environmental issues such as biodiversity, which suggests that chemical companies should begin to develop strategic plans to monitor and manage local impacts on biological resources.

4.3.2 Human Capital

THREE WAYS IN WHICH THE CHEMICAL INDUSTRY 'MANIFESTS' ITSELF		
As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
• Implement (continuous) employee training and development schemes • Develop leadership • Implement diversity and inclusiveness programmes • Protect health and safety of employees • Provide opportunities for personal growth	• Eliminate negative health and safety impacts of products • Design products that meet human needs and enhance quality of life	• Foster local employment • Develop employee volunteering programmes • Engage in dialogue • Protect human rights

The contribution of the chemical industry to human capital will initially be more difficult to measure as fewer metrics are available when compared to the wealth of data and indicators available in the field of environmental science. However, in a business context, human capital is primarily concerned with responsibility to employees and the creation of a high quality work environment.

The *Buried Treasure* report produced by SustainAbility evaluated a range of evidence and concluded that high quality workplace conditions can positively contribute to business success through increased shareholder value and the potential for innovation, improved revenue and operational efficiency, and may help to attract and retain staff.

Specifically included within this particular dimension of sustainability is the need to deliver appropriate and continuous training and development programmes. It is important to remember that the matrix implies integration and therefore an important outcome of such training programmes would be to equip all employees with sufficient knowledge to make decisions and act in ways that improve the sustainability performance of the industry.

In relation to the human impacts of its products, the most significant concern for the industry is related to their potential health and safety impacts. This has obvious links to the potential contribution of the industry's products to natural capital, and it is unlikely that such concerns could be dealt with in isolation.

The community dimension of human capital is concerned with the industry's relation to individual participants within the community, including the involvement of the community in decision making processes via open and trusted dialogue through to the development of employment opportunities for members of the local community. While the direct financial returns of such activities are unclear, they are essential to the reputation of the industry and the maintenance of its licence to operate.

4.3.3 Social Capital

THREE WAYS IN WHICH THE CHEMICAL INDUSTRY 'MANIFESTS' ITSELF		
As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
• Encourage local procurement • Ensure that employees understand company vision, policies and programmes. • Support and encourage progressive regulation	• Communicate information related to product performance, risks and appropriate use. • Assist consumers to understand the impact of their actions and consumption patterns.	• Sustainability performance is openly and accurately communicated • Develop partnerships with the local community • Involved in education programmes • Community investment programme aligned to sustainable development

The contribution of the chemical industry to social capital is concerned with its respect and support for various societal structures and groups. At the level of the business this is expressed through the industry's procurement activities, which can be directed to support the economic stability of small, local enterprise. However, it is also concerned with efforts above and beyond technical training and development programmes that are designed to ensure the businesses and employees, which collectively make up the industry, understand and are committed to the overarching vision, policies and programmes to deliver sustainability.

Also covered by this particular element of the industry's sustainability is the relationship between employees and the local community. This could include employee volunteering programmes and community partnerships that provide opportunities to increase participation, motivation and allow both employees and local people to use their skills in new and creative ways.

Another critical area in which the chemical industry will need to consider its contribution to social capital is the way in which it influences the public policy agenda. There is clearly a need for business to be involved with the regulatory process. If the chemical industry is to achieve sustainability the nature of its lobbying activities will have integrate environmental and social concerns, to ensure the regulatory process creates a framework which enables the industry to meet its environmental and social goals.

A further element to be considered in relation to social sustainability of the industry is related to its communication activities, both about its products and its sustainability performance more generally. While some individual companies have published environmental reports, far fewer numbers are reporting systematically on the overall sustainability performance of their operations. While the production of greater numbers of individual company "sustainability" reports will be important, the industry as a whole will be required to engage much more publicly in the provision of information to its stakeholders. Such communication must be open and transparent and demonstrate both qualitatively and quantitatively the increasing sustainability of the industry, the processes employed and the products that are used and produced.

At the community level, such communication efforts are required to develop from one-way reporting to include effective engagement. Such engagement is likely to encompass many of the activities described in the section dealing with human capital, such as stakeholder dialogue and community investment partnerships. This engagement would also extend to the education of suppliers, customers.

It is also important to consider the engagement of the industry in the education of science and chemistry to ensure that it incorporates all aspects of sustainability. The recent inclusion of sustainable development within the national curriculum may provide an opportunity for the industry to develop a more cohesive approach to its communication in the field of learning and education.

It is noted that education activities can and should extend beyond the school audience. Adult education will be an important precondition of sustainability as shifting existing attitudes and values will be an important factor in securing a licence to operate and their behaviour as consumers will be an significant driver for sustainable development. The chemical industry has already begun to engage in wider educational activities such as the CIA's friend or foe programme. It is important that such education programmes provide a balanced view of the issues, and engage with other organisations to develop their content to provide the programmes with greater credibility.

4.3.4 Manufactured Capital

THREE WAYS IN WHICH THE CHEMICAL INDUSTRY 'MANIFESTS' ITSELF		
As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
• Maximise process efficiency • Reduce volumes of throughput (energy, raw materials etc) for each unit of output) • Audit supply chain performance	• Infrastructure encourages product reuse and recycling	• Provide communities with appropriate access to and use of physical assets

The implications of improving manufactured capital overlap significantly with a number of the concerns identified as part of the possible contribution by the industry to natural capital. This overlap is most apparent in relation to the industry's role as a business enterprise, as a specific focus within this element of the matrix is the efficiency of physical assets.

At the community level, sustainable asset use also encompasses the idea of access and is therefore also closely linked to social capital. The industry should seek out opportunities to improve access generally and also for specific members of the community (including employees) who may be prone to exclusion for example, through disability. It is important also to consider access beyond exclusion to include the use of existing facilities and infrastructure by the community.

Shell's operations in France provide an interesting example of where access and community investment initiatives combined. As Shell scaled down its operation in France, significant areas of office space and infrastructure could have been sold on or left empty for considerable time. However, the company refurbished the existing infrastructure to create a whole new business park, where different business can share the resources available. This initiative has minimised the negative effects of retrenchment and created a number of benefits for the community.

4.3.5 Financial Capital

THREE WAYS IN WHICH THE CHEMICAL INDUSTRY 'MANIFESTS' ITSELF		
As a business, accountable to shareholders	**As a provider of products and services**	**As a significant member of the community where it operates**
• Makes acceptable financial returns • Account for total cost of activities encompassing both intangibles, risk and externalities • Shift the focus of management compensation from short term financial performance to include areas of sustainability performance	• Total cost accounting is reflected along value chain • Create economically viable products • Research and development priorities aligned to sustainability objectives	• Contribute to local economies through appropriate taxation in all areas of operation. • Eliminate corruption • Philanthropy aligned to strategic vision of company • Systematically avoid any "legacy effects" associated with operations and products

Being fully accountable to stakeholders will require the industry to measure performance using both financial and non-financial measures; and the industry should consider making a first attempt, crudely if necessary, to measure intangible assets and develop full-cost accounting procedures.

A number of companies outside the sector are currently engaged in environmental accounting in an attempt to place a financial value on the wider environmental and social impacts of their operations. The number of companies engaged in such activities is likely to grow as the professional accounting bodies, financial analysts and other stakeholders begin to demand the disclosure and reporting of environmentally related financial data to enable them to distinguish between good and bad performers.

Sustainability considerations should also be incorporated into the industry's financial and capital investment behaviour. In relation to capital investments, this will require the industry to design sustainability considerations into all new investments, and to measure the performance of the investment against environmental and social criteria. Perhaps most importantly, sustainability will require the industry to think more carefully about the long-term implications of its activities and decision-making. As such, the chemical industry should consider extending the pay back period of investments, especially where there are significant environmental and social benefits to be gained.

Many of the impacts identified in relation to financial sustainability, such as the need to remain profitable, to create viable products and to contribute to civic finance through the payment of taxes, will be common place in the industry. The systems responsible for delivering these benefits must continue to develop. However, recent developments within the business community highlighting the practice of fraud and the misrepresentation of company finances will also require the chemical industry to develop systems to prevent corruption and encourage ethical accounting procedures.

5 EXISTING PRACTICE

Having identified a number of key characteristics of a sustainable chemical industry in section 4, this section seeks to determine the current performance of the industry against existing key indicators of sustainability. Examples of good practice that could be adopted and developed by the chemical industry as it takes forward a range of sustainability focused programmes are also highlighted. Such examples of good practice are drawn from around the globe and examples from the chemical industry are discussed along side programmes developed by the manufacturing industry and business community more widely.

5.1 DETERMINING A BASELINE OF PERFORMANCE

It is important to determine a broad overview of the current contribution of the chemical industry to sustainable development. One of the ways in which it is possible to make a quantifiable assessment is through the use of existing indicators of progress. There are a huge number of indicators in the UK Government's "Quality of Life" counts. The headline indicators of direct relevance to the industry and a brief analysis of progress against a range of metrics are provided in the table below.

For clarity the indicators are set within the 5 capitals framework already discussed. It should be noted that the Government's definition of sustainable development does not make specific reference to manufactured capital and as such none of the indicators currently available deal specifically with performance in this area.

CAPITAL	GOVERNMENT HEADLINE INDICATORS	SPECIFIC METRICS	INDUSTRY PERFORMANCE
NATURAL	WILDLIFE AND LANDUSE	Biodiversity action plans	No specific performance measures currently available. However, the industry has created and manages many wildlife reserves on contaminated land
	WASTE	Waste arisings and recycling	At present the chemical industry accounts for around 12% of all the special waste produced in the UK. For all waste, recycling has increased from 16.5% in 2000 to 25.6% in 2001, while landfill has reduced by 2% and now accounts for 55.1% of the total disposal routes. Recycling of 'special waste' by energy recovery or reprocessing has increased from 39% in 2000 to 52% in 2001.

		Hazardous waste	In the last decade, the chemical industry has virtually eliminated the discharge of the RED List substances to water by a reduction of 96% . The industry produced a similar amount of "Special Waste", waste that is either hazardous or difficult to dispose of, in 2001 as it did in 2000.
	CLIMATE CHANGE	Energy consumption	Since 1990, the total energy consumption of the EU chemical industry has increased by 1%. However, energy consumption per unit of output has fallen from 100 in 1990 to 78 in 1999. In 2000, energy consumption per unit of production for the EU chemical industry was 51% lower than it was in 1980.
		Energy efficiency	Under the Climate Change agreement with the government , the chemical industry is committed to improve energy efficiency by 34% between 1990-2010. Energy efficiency data for 2001 is not currently available because the CIA is awaiting the completion of electronic data collection to support the CCA. The EU chemical industry has set an overall objective of reducing emissions of the Kyoto Basket of greenhouse gases by 30% by the year 2010. Since 1990, the EU chemical industry has reduced CO_2 emissions by 9%. As a result, CO_2 emissions per unit of energy consumption have been dramatically reduced, and CO_2 emissions per unit of production have decreased almost 34% since 1990.
	WATER QUALITY	Water consumption and chemical releases to water	In 2001, the total intake of water for the chemical industry was 972,000 mega litres (a decrease of 13 per cent compared with 2000). This was primarily due to the reduction in the use of seawater. The bulk of the water usage comes from the sea and rivers; nine per cent was from public (potable) water supplies

	AIR QUALITY	Chemical releases to the environment	Since 1995, the industry has reduced its volatile organic compound (VOC) emissions by over 60 per cent. Approximately 10 per cent of industry sites discharge phosphorus compounds; 26 per cent nitrogen compounds; and 65 per cent compounds which create COD In 2000, the emission of Nitrogen compounds was reduced by 25% compared to 1996. The emission of Chemical Oxygen Demand (COD) and Heavy metals were reduced respectively by 17% and 43%.
HUMAN	EDUCATION	Business recognised as Investors in People	The UK chemical industry spends around £400m p.a. on training. Chemical companies are at the forefront of initiatives to further improve employee development by: - seeking investors in People status (over 60% are now committed - adopting NVQ & SVQ programmes - implementing modern apprenticeships for 16-21 year olds in key occupations (1/4 of young people are now covered) - developing a Workforce Development Plan for the industry
	EMPLOYMENT	People in employment working long hours	Employment in chemicals steadily declining. No information available in relation to hours of employment.
	HEALTH	Expected years of healthy life	Over the last decade, the CIA has reduced their employee injury rate by a factor of 2. Between 1986 - 2000, the lost time accident frequency rate per 100,000 hours worked has fallen from 0.85 to 0.31. In 2000, the total number of fatalities in the EU chemical industry increased over the previous year but overall, the trend continues downwards (the effects of Toulouse are not yet included). The Lost Time Injury Rate is now around 10 accidents per million hours worked which is better than most other industry sectors. In 2000, the Lost Time Injury Frequency Rate (LTIFR)* is 21% lower compared to that in 1996.
SOCIAL	POVERTY & SOCIAL EXCLUSION	Ethnic minority employment	Information currently not available

		Environmental reporting	The number of manufacturing sites reporting formal health and safety and environment management systems has remained relatively constant (health and safety at 82 per cent and environment at 78 per cent). The number of third party certified environmental systems has increased steadily (30 per cent in 2000, 36 per cent in 2001) but third party health and safety certification remains at 10 per cent.
MANUFACTURED	No specific indicators available at this time.		
FINANCIAL	ECONOMIC OUTPUT	Total output (GDP and GDP per head)	2% of UK GDP
	INVESTMENT	Expenditure on pollution abatement	The manufacture of chemicals, chemical products and man-made fibres sector spent approximately £540m on environmental protection measures. This represents 1.1? of this sector's total turnover and about £2000 per employee. In 1999 the industry spent £440m (0.9% of total turnover) associated with the operation of pollution control abatement equipment and payments to external organisations for environmental services.
		Total and social investment as a percentage of GDP	Total investment as a percentage of GDP currently not available. The UK chemical industry spent £2.8bn on new capital investment in 2000. This represents 16% of total manufacturing investment.

5.2 RESPONSIBLE CARE

The chemical industry's Responsible Care programme continues to be implemented throughout the globe, with 46 countries now embracing the initiative, promoted from within the chemical industry as a comprehensive and effective framework for achieving performance improvements on a voluntary basis.

Many of the improvements above have been made as a direct result of the Responsible Care programme and there are a number of examples that suggest that Responsible Care has been used successfully to improve the health, safety and environmental performance of individual businesses. However, the International Council of Chemical Associations (ICCA) recognise that inconsistent implementation, performance and verification around the world and the inability to show quantitatively that HSE performance is systematically improving on a global basis presents a number of challenges for the future development of Responsible Care. The following section provides a brief analysis of the Responsible Care programme and its contribution to the wider goal of sustainable development.

5.2.1 An Analysis of Responsible Care

The International Council of Chemical Association's (ICCA) recent paper submitted to the United Nations' Environmental Programme (UNEP) in preparation for the World Summit for Sustainable Development (WSSD) provided a SWOT analysis of the Responsible Care initiative. This section highlights those elements of the analysis that are most obviously linked to the issues already discussed within this paper. The following section acts to make explicit the links (or lack of them) between Responsible Care and sustainable development.

The main strengths attributed to the Responsible Care initiative is the perception by many within the industry that it provides a comprehensive and effective framework for improving HSE performance. Certainly, where performance is measured there are indications of progress and behavioural change within individuals business and the industry more generally. However, the recognition of Responsible Care among both employees and the general public is fairly low and the ICCA report notes that Responsible Care terminology is not necessarily used in HSE training and education. The lack of attention to specific initiatives such as Responsible Care may be related to the proliferation of environmental management systems, including EMAS and ISO14001 that the report notes are "often merged into one general HSE or even broader quality and product stewardship management system at plant level".

The lack of external knowledge and engagement with Responsible Care is extremely problematic. NGOs and others remain outside the process, unable to contribute to the future of the initiative. Improved dialogue with external stakeholders and successfully communicating the industry's change in performance will be essential if the industry is to understand and be proactive in the management of stakeholder concerns. It will also be an important factor in building mutual trust and respect between the industry and its stakeholders, and if external audiences are to understand the relationship between Responsible Care and other issues under the umbrella of sustainable development.

5.2.2 Responsible Care and Sustainable Development

Responsible Care has been active within the UK's chemical industry for over ten years. In that time a number of the principles and other features of the Responsible Care programme have evolved to incorporate developments in public policy and stakeholder expectations. Most recently, there has been some debate, both inside and outside the industry, as to whether Responsible Care should be adapted to address all the dimensions of sustainable development.

A number of leading chemical companies have issued statements on sustainable development and in some cases have begun to report publicly on their performance against sustainability goals. Moreover, the CIA and other national federations, are already proactively engaged in the debate surrounding sustainable development within the industry.

While the chemical industry already addresses some of the requirements of sustainable development through its commitment to Responsible Care, the initiative in itself has not been specifically designed as a vehicle to promote or communicate a strategic vision and approach to sustainable development. In essence, Responsible Care is tool that can be used to manage incremental improvements in environmental protection, product stewardship and occupational health and safety. To fully address the philosophy of sustainability and the operational implications of progress towards this vision would require significant changes to Responsible Care.

As we have seen in section 4, if the chemical industry is to contribute significantly to sustainable development it will have to consider and integrate a range of additional topics into its current decision making and management processes. Currently, the most obvious gaps between Responsible Care and any approach to sustainable development are the social components such as, stakeholder dialogue, human and workforce rights, and community relations. However, the apparent gaps are not limited to social criteria but extend to include considerations such as the absolute reductions in resource above and beyond improved efficiency, and the need to capture and reflect the true economic costs and benefits of the industry's activities.

Undoubtedly, Responsible Care provides a platform on which the industry could begin to develop its approach to more sustainable development. While discussions continue as to whether this implies the expansion of Responsible Care to cover all aspects of sustainability or the development of an additional programme to fill the existing gaps, in reality the change necessary to ensure sustainability will be both more profound and widespread.

5.3 PRIORITY LISTS

One of the most popular approaches to more sustainable chemical use to appear has been that of priority lists. The priority list approach undoubtedly simplifies decision-making in organisational decisions, particularly those made by buyers and other staff without detailed chemical knowledge. They also allow organisations to set hard targets for phase-out and for screening of formulations and chemicals in use within their processes, and for reporting upon progress with identified targets.

As well as improving management, priority lists and the subsequent phase-out of specific chemicals may also create an incentive for innovation as chemical companies seek to develop substances that are not subject to the same levels of concern nor are likely to be in the future.

However, there are a number of concerns with the reliance of priority lists to deliver more sustainable development within the chemical sector. Most notably, there is a danger of encouraging short-sighted substitution decisions that phase out acknowledged problem substances but phase in unknown (and not necessarily more benign) substances and of overlooking the critical importance of how materials are used, which is critical to sustainability.

Simple lists may also act to avert thinking about strategic solutions and material stewardship and be rendered rapidly out-of-date as new man-made chemicals continue to be manufactured and used. Given that we know very little about the environmental behaviour and chronic effects of the 100,000 or so man-made chemicals estimated to be in current use, by overly simplistic listing we run the risk of merely removing a few substances with high media profiles.

5.4 SPECIFIC EXAMPLES OF GOOD PRACTICE

NATURAL	The global purchasing team at BASF not only negotiate contract terms, but also assess product and supplier risk. This involves using a safety matrix in which all products are classified into hazard categories A, B and C depending on their chemical properties, and suppliers into categories 1 (OECD countries), 2 (countries which have gone up or down a category) and 3 (all non-OECD countries). Products assigned a C3 rating present a potentially higher risk and are reviewed on a case-by-case basis. This means that a BASF employee from Raw Materials Purchasing visits the supplier and carries out an environmental and safety assessment to ascertain whether they operate effluent treatment plants to minimise pollution and use safety standards that comply with Responsible Care. BASF’s assessment of suppliers is designed to identify those companies that could benefit from BASF’s expertise in dealing with environmental and safety issues For example, one of the company’s suppliers, when audited in August 2000, displayed a good overall performance, but did not comply with some of BASF´s environment, safety and health standards. Employees from BASF helped the supplier to prepare an action plan to remedy the problems. Among other things, this involved changing the supplier´s production processes from open to closed systems and the provision of suitable protective equipment for employees. Five months later, following numerous on-site consultations with BASF, the supplier was able to meet the various standards and BASF began purchasing raw materials from the company on a regular basis.

NATURAL	3M Canada have developed a way of reducing pesticide use in forests and in agriculture by using pheromones to disrupt the mating pattern of insects that damage crops. The technology encapsulates chemically active compounds (in this case synthetic pheromones) within microscopic capsules, which release the pheromones into the natural environment over time. By mimicking natural pheromones the volume of pesticides (often toxic, persistent chemical compounds) non-target species are not harmed. There is also significant reduction in risk to human health as workers exposure to toxic chemicals is minimised and the application leaves no residues on food crops.
	Each Bayer product is analysed and assessed in six areas. For the area "Environment," for example, the parameters tested are acute and chronic ecotoxicity, possible bioaccumulation, biodegradability and the paths via which the product can enter the environment. For every area, the result of the test is categorised according to a five-step scale: from "very favourable" to "very unfavourable". This results in the "current status" of the product. In addition, recommendations for improvement can be submitted for every area. This is a considerable advantage because it enables Bayer to optimise the product across-the-board in terms of sustainable development. Alternatively, a product can be found to no longer meet standards and must therefore be withdrawn from the development portfolio if it cannot be improved or further developed.
	BASF coatings business has developed materials that can be collected by ultrafiltration and reused, benefiting the environment. The company's eco-efficiency analysis, which assesses the economic and environmental benefits of the alternatives, has shown that the process is both commercially justifiable and makes paint recycling profitable.

NATURAL	Some leading chemical companies are beginning to sell services rather than kilograms of chemicals. Contracts between the company and the customer ensure that, for example, the end user has a clean stack or painted part rather than providing a specific product, and this provides greater scope for creativity in finding the most efficient way of fulfilling customers' needs. Chemical management services (CMS) are now widespread in North America and are creating both reduced use of chemicals by, and financial savings for, customers in the auto, electronics and other industries. For example, General Motors' Saturn division approached Henkel Chemical Management to provide water-treatment services. The company now provides a whole range of services to Saturn including chemical purchasing and environmental tracking. The Chrysler Neon assembly plant in Illinois has a "Pay as Painted" contract with PPG. As part of the contract PPG provides all auto body surface preparation, treatment and coating chemicals until they are used and PPG is not paid until a quality car is produced. Therefore, the supplier's profitability is based on better service and increased value, not on the volume of chemical sold. The arrangement has helped Saturn dramatically reduce the cost of chemical products and processes. For Chrysler there have been addition benefits in the form of reduced VOC emissions, easier compliance reporting and improved product quality.

HUMAN The energy, motivation, capacity for relationships, and intelligence of individuals	Following a request by Design Tex to create an aesthetically unique fabric that was also ecologically intelligent the team at McDonough Braungart Design Chemistry (MBDC) decided to design a fabric so safe that one could literally eat it and whose trimmings could be made into mulch for the garden. To achieve this the design team decided on a mixture of safe, pesticide-free plant and animal fibres for the fabric and began working on the finishes, dyes, and other processing chemicals. If the fabric was to go back into the soil safely, it had to be free of mutagens, carcinogens, heavy metals, endocrine disrupters, persistent toxic substances, and bio-accumulative substances. Sixty chemical companies were approached about joining the project, and all declined, uncomfortable with the idea of exposing their chemistry to the kind of scrutiny necessary. Finally one European company, Ciba-Geigy, agreed to join.
	As a company that developed adhesives containing toluene, Henkel Chile was faced with health issues, such as glue sniffing, as a consequence of this additive. Toluene is an organic solvent. If used as directed, it is a safe product, however toluene, and toluene containing blends of solvents, have proven to be highly attractive for sniffing addicts. Also, toxicological properties of solvents containing toluene are closely observed by industrial and craftsmen clients from an occupational health and safety point of view. Henkel Chile changed its formulations for contact cements and created a toluene free solvent that satisfied price/performance considerations and other client and government concerns. The new solution is a blend of cyclohexane and acetone. Occupational concentrations of the new solvent have no adverse effects on the peripheral nervous system and it has no sniffing attractiveness to addicts and by offering equivalent performance the company has secured additional market share.

HUMAN	Bayer's Consumer Care Business Group in Brazil works only with suppliers who do not permit child labour and who provide regular financial support for social projects. The group also supports child-aid programs as part of its collaboration with Abrinq and is authorized to use the Abrinq logo that shows it is a child-friendly company. This logo is only awarded to companies who observe the principles laid down in the UN's 1989 Convention on the Rights of the Child.
SOCIAL The social groupings that add value to individuals (e.g. families, communities, parliaments, universities)	Helping farmers to apply the correct amount of nutrients is an important driving force of Hydro Agri and embedded in Norsk Hydro's focus on sustainability. To achieve this goal Hydro Agri has designed the Farmer Decision Support Tools Program with the objective of developing advanced and efficient, but easy to use, tools to deal with the problem. Such tools will assist farmers in determining the right amount and the best timing of fertiliser application, significantly reducing the instances of incorrect use of fertiliser that lead to nutrient losses and a negative impact the environment
	In recognition of the need to communicate with stakeholders the Novo Group have, since 1993, published annual environmental performance reports, and in 1999 their first social report was published. In 2000, the two reports were combined. As an acknowledgement of their efforts, the Institute of State Authorised Public Accountants in Denmark and the Danish newspaper Børsen awarded the Novo Group the prize for "Best Sustainability Report" for the 1999 Environmental and Social Report. In 2000, the United Nations Environment Program (UNEP) and the sustainable development consultancy SustainAbility performed the first international benchmarking analysis of combined social and environmental reports. The study ranked BAA (British Airport Administration) and the Novo Group highest among the top 50 reports analysed.

SOCIAL	Contract chemicals were asked to consider donating money to help a local regeneration project. Instead of just giving money to the project the company asked a contractor to carry out a survey of the project and quote for the work. By giving time and expertise the company was able to save the project £150,000 and notes a range of other benefits associated with the use of its skills in terms of the ability to offer employees ways to express and develop their skills in new and creative ways.
	Right next to Bayer's site in Belford Roxo the company has a large sports facility, including a soccer field. Because soccer is the most popular sport in Brazil, it makes sense to support it. In 1990, Bayer set up a special soccer-training program for children. Training sessions were held several times a week for about 350 disadvantaged children aged between eight and 17. Professional trainers and medical and psychological care are an integral part of this program. Only children who can prove that they attend school and get good grades are allowed to take part. That is an enormous incentive for these children to attend school regularly.
MANUFACTURED Can the "stuff" that already exists be used in a way that requires less resources and more human creativity	BASF is making considerable savings related to infrastructure and logistics through its Ecologistix software that compares the economic and environmental impact of transportation methodologies. Using the analysis, BASF now transports styrene by rail between two sites in NL. Although the costs were slightly higher the environmental impact (in terms of energy consumption, emission and health risks to workers) is significantly lower.

MANUFACTURED	BASF uses a system that it calls "the Verbund". In physical terms it is a dense network of interconnected production plants in which the by-product from one plant often serves as the basis for production in another plant. However, the BASF Verbund also stands for the worldwide exchange of knowledge across regional and organisational boundaries. The transfer of knowledge and the networking of production plants, energy and waste flows, logistics and infrastructure help BASF to improve process efficiency.
	SAFECHEM, a subsidiary of Dow, has developed a handling system for chlorinated solvents that enables them to be used within closed loop technical cycles. The system uses two containers, one to hold fresh solvent the other used solvent. The containers are then connected to the cleaning equipment with special leak free connections that prevent spills, leaks or vapour emissions in use. The whole system not only reduces solvent use and harmful releases to the natural environment but also allows used solvent to be collected for recycling.
FINANCIAL The money, stocks etc. that enable us to put a value on, and buy and sell, the above resources. Ways that value can more accurately represent the real 'cost' of using them?	A number of organisations have begun to systematically collect internal environmental expenditure and a limited number have externally reported this information. For example, Baxter Healthcare have published an Environmental Financial Statement which shows their total environmental expenditure and associated savings over a number of years. Some companies have gone further. For example, Wessex Water has produced statement of environmental accountability, showing the estimated "environmentally sustainable profits", which are calculated by subtracting the costs associated with the company's environmental impact from the net profit figure. Accounting for the impacts a business is responsible for makes sense from a pure business perspective. Being aware of all aspects of a company's performance is critical in determining possible risks; potential liabilities; responding in a cost-effective way to future regulation and avoiding bad publicity and reputational damage.

FINANCIAL	BP reward system is run through a system of performance contracts. These contracts set targets for performance and exist at various levels within the company. The contracts are typically concerned with three areas: • Financial/ production performance. • Health, safety and environment (HSE) performance. • People performance (e.g. appraisals completed). The aim of this system is to cascade overall business objectives and targets through the organisation. Where stretch targets are in place these will be linked to higher increments in the bonus scheme. This can be lowered significantly by specific incidents (eg fatalities) that are heavily penalised by the company.

6 CONCLUSIONS

This section provides the overall conclusions of the report. These conclusions are based on a number of headline recommendations. Within each of these particular areas are a number of more specific areas for action.

Recommendation 1:
Establish a clear and robust vision of sustainability. This should be actively involve the industry's key stakeholder and build on the findings of this report

Recommendation 2:
Establish a strategic framework for decision making related to achieving sustainability within the industry. This framework should make reference to key considerations for sustainability including dematerialisation, chemical use and the inherent properties of chemicals and their compounds.

Recommendation 3:
The industry and individual business within the sector should extend the scope of current reporting to include a wider range of sustainability issues and stakeholder concerns.

Recommendation 4:
Commit to the introduction of sustainability training programmes designed to develop skills and build capacity within the industry.

Recommendation 5:
The industry should act to support and promote public policy decisions that are aligned to the needs of sustainable development and the vision of sustainability within the industry.

6.1 ESTABLISH A VISION

While it is possible to conceptualise, the chemical industry has yet to establish and communicate a clear, overarching and long-term vision of sustainability. As a clear vision lies at the heart of any approach towards sustainability we would recommend that the industry begin to define a vision of sustainability with reference to both its processes and products.

Simply put, in a sustainable future, our use of chemicals will not result in the systematic increase in concentration of man-made materials in natural systems (including of breakdown products), physical depletion of nature, or undermine human needs.

If the chemical industry is to realise the huge potential of sustainability for its companies, customers, employees, society and the environment, sustainable development must not only been accepted as a permanent fact of business life. It will be essential to embed the ideals and make them meaningful for everyone within the industry through an ambitious programme of action designed to move the industry toward compliance with the vision.

The sustainability matrix suggests that main features of this action plan should include reference to the following:

The use of renewable and recycled raw materials
Using scarce or depleting resources means that the industry is vulnerable to price fluctuations and ultimately lacks security of supply in the long-term. Sustainability will require the industry to use significantly less petroleum based raw materials in the productions process and to actively seek to use more sustainable alternatives.

The use of renewable energy
Currently our society relies heavily on a finite supply or fossil based fuels, which places six billion tonnes of carbon emissions into the atmosphere every year when burnt, making a significant contribution to global climate change. Given that the current rate of CO_2 emissions into the atmosphere is unsustainable, the chemical industry, along with other sectors, will have to increase the total amount of renewable energy it uses throughout its operations.

The total environmental impact for both products and processes
Sustainability will require that the negative environmental impact of both products and processes are eliminated, or at least significantly reduced. Some of these impacts will be associated with energy use and raw materials (discussed above) but will extend to include a range of issues such as water consumption and waste production.

The health and safety risk to employees and society through the products made available.
A number of properties within certain chemicals cause concern in relation to the possible negative health effects associated with their handling by employees and to the end user throughout the lifecycle of a product in which they are found. The industry will have to reduce and eliminate, wherever possible, the potential risk to human health associated with its products and processes.

The education and skills of present and future employees, contractors and suppliers necessary to deliver sustainable development within the industry
Delivering sustainability within the industry will require that everyone involved understands his or her individual responsibilities in achieving more sustainable development. This will require that employees, whether present or future, have the appropriate competencies to make and implement decisions that encourage more sustainable development.

Engagement in the debate with the public and regulators
The industry should support the societal process of sustainable development i.e. the industry's actions should not subvert but support the intention or meaning of legislation designed to foster more sustainable development.

The delivery of economic performance
Good economic performance is essential to ensure that the industry is attractive to investors in a competitive environment, albeit with increasing emphasis on the

importance of environmental and social performance of business and industry more widely.

However, if the vision is to be transparent and the accountability of the industry improved both the visioning process and the development of subsequent plans of action will have to actively a range of stakeholders. It is noted that the ICCA has recognised the need for and to implement effective partnerships with a wide range of stakeholders. Certainly, sustainable development will demand not only better dialogue with the industry's stakeholders but also effective partnerships whenever possible. Therefore, the industry should identify a range of partners for involvement in dialogue activities on sustainability issues in the chemical sector.

6.2 ESTABLISH A STRATEGIC FRAMEWORK FOR DECISION MAKING

The key challenge will be for the industry to think about systemic change at the highest level and to recognise that sustainability will require more significant action than minimising the negative impact of current products and processes. It will require the industry to be creative and innovative in its approach to ensure that the solutions it delivers integrate fully the needs of the economy, society and the environment.

In integrating sustainable development into all of its activities the industry will have to consider the following:

Dematerialisation: Can the *service* be supplied in ways that use no (or less) material? See section 6.2.1		
↓		
Can material use be adapted to prevent harmful effects on the natural environment? See section 6.2.2	→	For example: Introduction of recycling schemes Elimination of troublesome additives Closed loop recycling Limitation to durable applications
↓		
Can we replace the material if cyclic use is not possible, and how have we assured ourselves that our choice is genuinely more sustainable?	→	Is the proposed substitute genuinely more sustainable?
↓		
Can we simplify decision-making about 'priority' chemicals? See section 6.2.3		
↓		
Can we drive innovation through our supply chain?	→	Few solutions will be made by any organisation *in isolation* Partners need to share this guide with their suppliers and contractors to engender true partnership.

6.2.1 Dematerialisation & Technical Cycling

Societal and business models based on a linear pattern of resource use – make, process, use and disposal represents not only a loss of resource but also of economic value. Recovering economic value and utility from used resources will be increasingly important in developing towards sustainability as it will maximise the true productivity of physical resources, while simultaneously helping to avert pollution. It is key therefore that whilst addressing the immediate problems with chemicals in the short term, the industry also look at how to tackle the fundamental problems associated with linear industrial processes.

The oft-quoted mantra of resource productivity and waste reduction – "reduce, reuse, recycle" – has yet to be implemented into the decision-making processes of many businesses. However, achieving sustainability will require that those specifying materials or designing products within and for the industry have a fuller understanding of the need for dematerialisation and the tighter cycling of materials.

Doing more while using fewer material resources is not alien to the chemical industry and has been expressed through a range of efficiency programmes. Such programmes are often the starting point of any business trying to develop towards sustainability as whatever "solution" is adopted it is possible to demonstrate reduced negative social and environmental impacts along with direct cost saving. Indeed, the chemical industry should continue to pursue energy efficiency improvements to reduce the suite of greenhouse gases and to promote efficiency and conservation in the use of water resources.

However, the more fundamental, and strategically important, question in relation to dematerialisation is whether the service provided by a particular product under consideration be met in a more sustainable manner through significant reductions in resource use. In essence, the challenge for the industry would be to design services that in the long term make the manufacturing and sale of products redundant.

Having explored dematerialisation it is then important to extend the usage of a material through either reuse or recycling. What society currently calls recycling might actually be considered as "down-cycling" as the recycling process is not always directed on a pathway that ensures the maximum benefit from reuse but instead acts only to create a short delay in the time to disposal. As such the highest value option for material reuse should be sought wherever possible. There is a clear role for the industry to work throughout the supply chain to ensure that materials are designed to be reuse and recycled in practice. It will also be important for government and industry to work together to ensure that the infrastructure and economics of such schemes support progressive change throughout the industry.

6.2.2 Chemical Use

No substance or material can automatically be considered "sustainable" or "harmless". It is the characteristics of the material throughout its lifecycle and its properties in use that are most important in determining its overall sustainability.

Therefore, simplistic proposals to substitute chemicals without appropriate analysis against all possible sustainability impacts could actually be counter-productive in the industry's attempts to achieve sustainability.

The ICCA suggests that the "the risks and benefits of a given chemical, candidate for substitution, should first be compared with those of competing products for a given application, using a selected set of criteria". We would recommend that the criteria used should compare the characteristics of materials in relation to how they are or will be used.

The Natural Step in the UK (see appendix A) is already working with a range of companies to develop an approach to chemical prioritisation and substitution. The Natural Step (TNS) model is based on the scientific principles of natural systems, the so-called system conditions. This research should inform the development of the industry's future approach to chemical analysis and substitution.

6.2.3 Chemical Properties

Chemical companies are constantly evaluating alternative products and manufacturing processes and therefore substitution of materials is intrinsic to the way industry conducts its operations. In the short term chemical designers should commit to reducing and eliminating properties such as bio-accumululation, persistence and toxicity in materials where the property is not essential. Influenced by the debate in Sweden and the approach of The Natural Step, the Swedish Parliament and National Chemical Inspectorate (KEMI) have already begun to put in a new chemicals policy based on a number of guiding principles.

New Products introduced onto the market are largely free from:

- Man-made organic substances that are persistent and liable to bioaccumulate, and from substances that give rise to such substances;
- Man-made substances that are carcinogenic, mutagenic and endocrine-disruptive – including those that have adverse effects on the reproductive system; and
- Mercury, cadmium, lead and their compounds.

The environment must be free from man-made substances and metals that represent a threat to health or biological diversity. This means that [by 2020]:

- The levels of substances that occur naturally in the environment must be close to background levels; and
- The levels of man-made substances in the environment must be close to zero.

Swedish Parliament

Figure 1: Swedish Parliament's guiding principles on chemical.

These principles are designed to systematically reduce many of the environmental impacts associated with chemicals in order to meet one of Sweden's Environmental Quality Objectives of a "non-toxic environment". The fundamental principle is to ban chemicals with inherently harmful properties and thus reduce the risk of negative impacts from chemicals in products through their entire lifecycle.

S C Johnson has adopted a systematic framework for the selection of chemicals that will ultimately make it into the company's huge range of products. The innovative approach that S C Johnson has adopted, the so-called "greenlist", scores various chemicals based on a number of criteria. These criteria are specific to the category of product, linked to the known chemical properties of the substance, and relevant to the final application of the product in use. This scoring system has real business benefits both in terms of S C Johnson's ability to proactively design products that use the best chemical substances, reduce the regulatory burden related to pre-manufacturing notice and to monitor the quality of their supply chains.

6.3 EXTEND THE SCOPE OF REPORTING

It is important that the industry extend the scope of current global HSE reporting to include the whole range of sustainability impacts that the industry is responsible for. For reporting to occur in a consistent and sensible manner at the sectoral level it will be important to agree a full range of sustainability indicators. The Global Reporting Initiative (GRI) provides an established template for reporting that could incorporate sector specific metrics, including some of the indicators already developed by the Institute of Chemical Engineers (IchemE).

Sectoral reporting is essential if the industry is to communicate progress towards the overall vision of sustainability already discussed in section 4 that can then be evaluated by stakeholders.

6.3.1 Individual business within the sector

As part of the sectoral reporting process, individual businesses will have to clearly set out their contribution to the industry's overall sustainability. The public reporting of key data related to sustainability management, including progress against specific indicators could be made a pre-requisite of membership to groups such the Chemical Industries Association (CIA). Currently members of the CIA are required to sign up to Responsible Care and while strengthening the Responsible Care Communication Code is necessary, it would require concerted effort by the industry at a global level. Therefore, it may be more practical in the interim for national associations to set specific reporting requirements

6.4 DEVELOPMENT SKILLS & CAPACITY BUILDING PROGRAMMES

Achieving sustainability will also entail the principles of sustainable development to be established throughout the value chain, from research and development through to production, sales, and logistics. It follows therefore, that the industry will have commit to introducing sustainable development training programmes for existing employees and become involved in the education of science and chemistry more broadly.

6.5 SUPPORT & PROMOTE PROACTIVE PUBLIC POLICY

As well as the obvious impact of sustainable development on the actions of the industry and its constituent companies, there is also a link to the industry's public policy position. For example, in relation to chemical risk, the industry must respect and support the right of governments to halt or limit the use of chemicals shown to have unacceptable risk. The industry could go further by carrying out such actions themselves with involvement of government and other stakeholders.

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7.1 WEB LINKS

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http://www.uneptie.org/outreach/wssd/docs/sectors/final/chemicals.pdf

http://www.wbcsd.org

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8 APPENDIX A: THE NATURAL STEP

The application of a science-based framework developed by The Natural Step (TNS) is a way in which organisations can begin to understand what sustainability means to them.The Natural Step (TNS) is an international body that helps organisations and communities move towards a sustainable future.

The Natural Step Framework is a methodology for successful organisational planning. In using TNS Framework, one proceeds on the basis of a future point in time when society is sustainable.

The prerequisite for this is an all-embracing definition of the conditions that must apply in any sustainable society. These conditions, known as the system conditions, are an important part of TNS Framework. They have been developed by an international network of scientists.

Planning with the help of TNS Framework focuses on the initial causes of problems rather than reacting to the environmental effects. Investments and measures are selected which develop the organisation in a sustainable direction with maximum long-term flexibility and short-term profitability.

TNS Framework is a methodology for all environmental planning. When environmental management systems, key indicators and lifecycle analysis are undertaken using TNS Framework, operations are steered in a sustainable direction.

The System Conditions

In the sustainable society, nature is not subject to systematically increasing....

...concentrations of substances extracted from the earth's crust.

... concentrations of substances produced by society.

... degradation by physical means.

and, in that society ...
... human needs are met worldwide.

8.1 APPENDIX A1; BIODEGRADABILITY VERSUS DURABILITY

It is established 'green' rhetoric that biodegradability is 'a good thing' whereas persistent substances are necessarily 'a bad thing'. There is no doubt that this simplistic mantra has been helpful in the early stages of *transmaterialisation*, or in other words substitution of some genuinely problematic substances with other more benign ones.

But, from the perspective of sustainable development, is life really that simple? Does it cover <u>all</u> applications of chemicals and materials, and offer the best chances of helping an exploding population meet its needs on the back of dwindling global resources? Indeed, has the instinct for 'one size fits all' answers to often complex questions meant that established but simplistic 'green' rhetoric is at odds with the real issues?

As we make more progress with sustainable development, and deepen our enquiry about the sustainability of materials we use, we are forced to ask deeper questions to which the answers are rarely simple. The Natural Step Framework was developed to deal with decision-making in complex systems. This paper explores the application of the TNS Framework to the often tough choice of material selection, and also explodes some of the myths surrounding the options available to us.

As long as we realise that a sustainable product or activity is one that does not contribute to increasing concentrations of substances (1) from the Earth's crust or (2) produced by society, and that it does not contribute to (3) physical degradation of nature, and does not (4) prevent others from meeting their needs – or in other words complies with the four System Conditions – then we open up for ourselves an enormous amount of possibilities for achieving that sustainable end-goal. If this process of visioning is dealt with in a brainstorming session, a wide range of strategies for achieving the desired end-goal become apparent.

Tackling System Conditions One and Two relates to preventing the accumulation of substances in nature, whilst also meeting the requirements of System Conditions Three and Four. There are many ways of preventing the accumulation of substances, and it is helpful to exercise our minds about the relevance of two that are commonly misunderstood as being on the extremes of available solutions: biodegradable and persistent materials

The use of **biodegradeable materials** is inherently sustainable where they can be safely broken down and reintegrated by natural processes. However:

Where the throughput of materials swamps nature's capacity to break down and safely reintegrate materials, we have problems such as eutrophication of waters and soils, deoxygenation due to excessive BOD (biochemical oxygen demand), etc. Maybe there needs to be a technical fix such as a treatment works to limit accumulation locally?

Where the demands on virgin resource to produce biodegradable materials is excessive, this is not only wasteful but also creates potentially more harm to nature than perhaps using a more long-lasting material that can be reused or recycled. (For example, it may take excessive resources to grow a crop-based substance, or large volumes of material may have to be dug out to extract a small amount of pure substance, or energy inputs may be excessive in the manufacturing/conversion process to create useful products – all this of course exacerbated where the products are not durable and will require more frequent replacement. All of these implications have to be factored into overall sustainability appraisal of materials in use.)

If biodegradable materials enter mixed waste streams, it would be naïve to think that they will quietly and benignly break down and be reintegrated with natural cycles. They will instead mix with all the other garbage in those waste streams contributing to problems such as complex seepage or the generation of methane and other problem gases. So, for example, just because the material was biodegradable does not mean that we should use it and dispose of it in the same old habitual ways. If we do, the main benefit we sought from it – biodegradability – merely adds to existing pollution streams and perpetuates linear use patterns!

None of the above considerations seek to undervalue the contribution that biodegradability may make to sustainable development, but illustrate the dangers of a too-simplistic pre-judgement that biodegradability is automatically 'better'.

The use of **persistent materials** may also satisfy the System Conditions where measures are taken to prevent accumulation in nature. (Examples include in durable applications with extended lives, inert materials such as mineral ceiling tiles or clay roof tiles or bricks, take-back and recovery of materials into closed loops at end-of-life, etc). These applications can be very resource efficient, allowing a small amount of carbon and other atoms to deliver social value over an extended life span. However:

Where additives inhibit cyclic reuse, or else break down throughout life or leach out at end of life, the loop is not fully closed and there exists the potential for problems.

The Second Law of Thermodynamics is a given, so we know that leakage from 'closed loop' cycles is inevitable. The issue is whether the 'leakage' is at a rate and of a type of molecule that nature can handle without exceeding its reintegration rates, such that increasing in concentrations are inevitable.

So in some instances persistent materials may offer a more efficient, durable, recyclable and sustainable use of materials. There are, however, risks that have to be investigated, quantified and managed.

Matching Solutions to the Context

It all depends upon context. Different solutions may seem contradictory, but may – if they are handled in the way the TNS backcasting methodology allows – just serve as different 'stepping stones' towards the identified end-goal of full sustainability. Two such apparently contradictory solutions to business challenges are provided below.

You could introduce materials that quickly degrade into compounds that are simple to assimilate into natural cycles. Typical things to look out for, and possibly cover for by subsequent 'stepping stones' *en route* to the goal of sustainability (if this is the strategy chosen by the group exploring more sustainable options within a company) would be:

Possible low performance of the material; and

Resource consumption (if you have to keep replacing products made out of the chosen material because they degrade too rapidly).

Alternatively, you could introduce materials that are very strong and durable. Typical things to look out for, and possibly tackle in subsequent 'stepping stones' *en route* to the goal of sustainability (if this is strategy selected by the group within a company), include:

Possible shedding of persistent unnatural compounds to nature during the life time of products;

Problematic issues associated with the material after end-of-use of products; or

Potentially problematic production methods which will need to be addressed over time. (Note that this point is not merely connected with durable materials as, for example, chlorine-bleached paper has production problems whereas a handmade stone wall has less associated chemical issues.)

Not All Applications are Equal

So, for both of these two broad categories of materials – biodegradable and persistent – there exists at least the theoretical possibility of sustainability, as well as the probability of unsustainability in the short- to medium-term that need to be tackled by suitable 'stepping stones' towards our stated end-goal of full sustainability!

Let's think through four practical examples of different applications to illustrate this:

<u>A piece of wood used in a window frame</u>. Wood is traditionally considered 'green', and particularly so where upstream implications have been well-managed, for example by certification under the FSC (Forestry Stewardship Council) scheme. However, wood in a window has a relatively short-life, relies on regular (typically five-yearly) application with new paint (effectively a soup of preservative chemicals) and is contaminated at end-of-life. Used wood is also hard to recycle! Conversely, a PVC window frame can be recycled after a life span that may at least in theory be 50 years. If the PVC frame is then merely burned, we have environmental problems, but if recycled – the loop is closed – those molecules can theoretically deliver social benefits for centuries!

Ink used on newsprint. This is a typical short-life application. We hope that the paper will be recycled, but linear disposal – perhaps with the low-value benefit of heat-recovery – is also likely. Composting is also a possibility. Were the ink to be recovered and recycled, then we could bear the use of some durable materials as this would limit release and accumulation in nature. But, assuming it is not, we would have to ensure both:

the elimination of persistent substances from inks from the Earth's crust or from man-made sources, which would in this application contribute to society's breaches of System Conditions One and Two, leading to potential bioaccumulation, toxicity, unforeseen effects, etc; and

benign methods of disposal or reuse to facilitate continuing beneficial reuse of material by society (for example as compost, building material, etc) or their re-entry into productive natural systems at a rate that nature could handle.

For our third example, let's choose plastics used in durable packaging applications. We have to consider the specifics of the use of the packaging to have deeper insight into routes to sustainability. For example:

If the packaging must be durable and can be reused and/or recycled at very high return rates – for instance pallets or returnable crates for transporting goods – there is a strong argument in favour of making them as strong as possible. Plastic may be an efficient means for doing this (with the added advantage of greater resistance to moisture, and the consequences of moisture content for the weight of wooden pallets and its implications for energy use in transport).

We obviously need to work towards the production of these plastics from renewable resources, and/or from substantially recycled and recyclable materials, that do not shed persistent unnatural compounds during their life span. Plastics in this application may actually save resources in comparison to wooden frames. An example would be to choose and use PVC or polyethylene without the release of any persistent plasticisers or stabilisers into nature (effected either by their phase-out, or ensuring that persistent materials are fully immobile in the plastic matrix and are fully recovered for reuse at end-of-life.)

Similar considerations would also apply to sewer pipes; long-life applications where biodegradability might be prejudicial to sustainability. A durable plastic might be an appropriate choice for a municipality or water service company trained in TNS principles who, for example, is keen to eliminate copper from its pipework on sustainability grounds. (Since copper is scarce in nature, society has already contributed to a considerable systematic increase in concentration, breaching System Condition One.) By avoiding more frequent replacement, we are not only more sustainable from a material perspective, but also avert expenses and disruption from infrastructure replacement (road-digging, etc).

The final example is <u>short-life packaging</u>, for which durable materials may be the least appropriate route to take. Say, for example, covers for food served in a drive-by restaurant, or indeed within that fast-food restaurant. The residual waste materials are contaminated, and therefore hard to sort and recycle (and also light so not economic to recycle). The overriding issue is to avoid product waste, including both the packaging and the food product it protects. Both have to be considered together, and we must not forget that current packaging technology, regardless of the other issues raised here, provides thermal insulation that prolongs the shelf-life of hot food that minimises wastage as the food is thrown away when too cold to sell. Existing packaging also offers barrier properties for controlled and modified atmospheres, which also increase longevity and prevent wastage.

The details above are provided not to baffle with detail, but to highlight the complexities that must be addressed in determining the best route to the sustainable use of materials in serving the specific application they are serving. (Consideration of hot food packaging introduces quite different considerations than, say, packaging for a cotton tee-shirt.) In this instance, it is doubtful that even degradable plastic would be more sustainable that genuinely biodegradable, naturally-sourced food packaging products <u>provided we designed them to cater for specific technical performance requirements</u>. We could, as one example, use leaves from a suitable indigenous plant species (this remains common practice in many developing countries) though would have to ensure that concerns about food contamination were fully addressed. A 'low-technology' solution such as untreated paper may better fill that need, though clearly in a short-life application of this nature we'd have to calculate the energy balance in determining overall sustainability (we'd probably need to avoid the types of grease-proof polymer coatings common on such papers today). We also have to consider in some detail the fate of these materials, which is hugely relevant to overall sustainability. Neither must we overlook other wider potential solutions, such as us taking our own plates along to the restaurant, or even calling into question the need for fast-food restaurants!

The four examples above demonstrate that the context in which materials are being used is everything. These different applications create different possible sustainable solutions. Over-simplistic 'one size fits all' generalisations about what is 'good' and 'bad', irrespective of context, seem inevitably to lead us into reduction without simplicity!

Further Notes and Emerging Principles

The issues raised above will, I hope, stimulate thinking and further discussion. They may, on the surface, appear to muddy the waters of decision-making. However, dive a little deeper, and you will see that they instead demonstrate how applying a simple System Condition-based analysis can help us cut through the complex issues around the choice of materials.

They certainly offer far greater insight and more strategic solutions than the simple 'one size fits all' dogmas that can merely drive us into investing in tomorrow's problems. They also force us to realise that we have to think of material use in terms both of the *pattern of use* of that material (critically including following end-of-life), and also the *specific application* for which the material is being used.

Five basic principles appear to emerge from this exploration:

There are no grounds for making any presumption in favour of either biodegradeable or durable materials as a universal solution to sustainability problems;

All applications have to be considered individually;

For both biodegradeable or durable materials, we should not just think in terms of substitution with 'off the shelf' alternatives, but recognise that the route to sustainability may be accelerated by recognising the need for innovation to adapt materials to meet the technical performance requirements of specific applications;

There is a broad tendency for durable materials to offer efficient means for meeting the needs of long-life applications, and for biodegradeable materials to best meet the sustainability pressures on short-life applications (including consumables); and

One must think wider than just the choice of material, as strategic sustainability solutions may lie in *meeting needs in alternative ways* rather than choosing different materials to suit existing applications. We must also focus on the full life cycle of the material, critically including after 'end of life' of products, as subsequent fate (reuse, recycling or disposal) has a huge bearing on overall sustainability).

Acknowledgement

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8.2 APPENDIX A2; ECOTOXICITY AND PRECAUTION

The four System Conditions of The Natural Step (TNS) emphasise the importance of the concept of *accumulation* of substances when assessing sustainability implications.

The Use of Ecotoxicity

The history of the control of pollution and chemical use has been one of reacting to adverse effects, particularly those with demonstrable or perceived human impacts. To a significant extent, this has reflected growing awareness of problems, at odds with implicit assumptions that novel substances and applications will have no impacts. (This tendency to be reactive applies equally for releases of chemicals and of microorganisms, particularly those associated with communicable diseases.) As our knowledge of the toxic effects of substances has increased, so too has the legislation and regulatory infrastructure put in place to control their use.

The discovery of endocrine disruption effects was a ‘wake up’ call, reminding us that known acute toxic effects are not the only cause for concern. Furthermore, such toxicity data that we have are at best partial, rarely if ever address chronic effects, and cannot account for the interactions of chemicals with others and within the complexity of the environment. Neither are chronic effects restricted purely to man-made chemicals as, for example, many natural compounds can be carcinogenic or have substantial endocrine disrupting capacities. (For example, some fern spores are highly carcinogenic, and soya exhibits one of the highest known levels of oestrogenic activity.)

Today, there is growing consensus that yesterday’s ecotoxicity-based approach can not simply be extrapolated into an increasingly complex future, in which society produces in excess of 100,000 synthetic substances, and as we become aware of increasingly subtle and chronic effects. Indeed, new legislation is emerging from the European Commission, including a ‘white paper’ on chemicals that is currently being drafted. We have to find ways to be better prepared for the unforeseen, and to articulate exactly what Paracelsus meant in modern regulatory thinking

Responses to Increasing Complexity

Enter the Precautionary Principle. Introduced around the time of the Rio de Janiero *Earth Summit*, the Precautionary Principle should be invoked where the potential *hazard* is substantial but the *risks* are not yet known. The Precautionary Principle goes well beyond known toxic effects, and provides a check on otherwise unconstrained development – of chemicals, their applications and wider human activities – that acknowledges potential risk.

The Precautionary Principle has however had a mixed reception. There are those (particularly within pressure groups) who believe it should be invoked ubiquitously for synthetic chemicals, placing a burden of proof upon proponents to demonstrate no risk – an impossibility in practice. Equally, many in business feel that the application of the Precautionary Principle has already been too sweeping, stifling innovation, investment and change. The truth may lie somewhere between these poles, as indeed does the expressed intent of the Precautionary Principle, although they do demonstrate the difficulty of applying the precautionary approach where toxic effects cannot be fully foreseen.

The Precautionary Principle and The Natural Step Framework

It is against this backdrop of the need to manage and innovate in the face of complexity that *systems thinking* has emerged. And the TNS Framework, based on a systems approach utilising the fundamental scientific principles underpinning the workings of this planet's life-support systems, has been developed to support practical decision-making about sustainable development.

The TNS Framework addresses conditions for sustainability. If the four TNS System Conditions are violated, the potential for adverse effects, whether foreseen or unforeseen, is certain. The Precautionary Principle need only be invoked when we don't know if the System Conditions are violated or not. This may occur, for example, where society plans to use a relatively persistent compound foreign to nature in relatively small amounts, but is uncertain whether the compounds will 'leak out' into natural systems in sufficient amounts to cause an increase in concentration. In this instance, the Precautionary Principle should be applied and further innovation sought, be that by (i) substitution of the material, (ii) ensuring that it can not escape into nature, or (iii) meeting the need in another way entirely.

This principle understanding makes it possible to manage chemical compounds *regardless of known toxic effects* and also to *apply the precautionary principle in ways that fuel rather than stifle innovation*. Since we can not predict all long-term effects of all substances, the TNS principles helps us make decisions that address the 'upstream' causes of problems rather than hoping that 'downstream' symptoms will be predictable, negligible or manageable. It also helps us avert future risk from health and safety, toxicity, liability or reputation issues, by addressing the systemic interaction of substances with nature and society.

This in effect sidesteps the Precautionary Principle by resetting risk to 100% where the potential exists for substances to accumulate in nature. It also neatly sidesteps the demand for ever more detailed and expensive toxicity data to support decision-making, since capacity for accumulation is the only parameter of concern. (Toxicity testing after all depends upon us knowing what effects we are looking for, and then only over relatively short time scales and in simple test systems.) By avoiding the often-conflicting ecotoxicity and precautionary approaches, TNS tools unblock obstacles to decision-making by focusing on big principles and not small details.

From System Theory to Practical Planning

The TNS System Conditions are neutral principles for sustainability, but don't give any guidance as regards the urgency of various breaches of them. Further information and business priorities need to be invoked when applying them in practical decision-making. Two examples are provided below:

Releases of both plutonium and iron violate System Condition One. However, we know that the far more serious toxic effects exhibited by plutonium make it the priority candidate for our attention. Nevertheless, the attainment of full sustainability requires us to address both releases in the longer term.

The relative costs of dealing with various breaches of System Conditions can also set business priorities. For example, it is considerably more expensive and complex to change fuel systems than it is to change coolants used in refrigeration, making the latter the immediate business priority with the quickest payback. Once again, both need to be addressed if we are to achieve the long-term goal of full sustainability.

Importantly, the System Conditions help us assess what flows and activities are currently unsustainable, and we can also use them to avoid solving old problems by inventing new ones. (For example, a modern-day equivalent of substituting CFCs with HCFCs.)

Application of the TNS Framework also provides us with a spur for innovation as there is no prescription of the means by which System Conditions may be satisfied. For example, we may choose to eliminate a potentially hazardous substance from applications, or alternatively put in place measures – reuse, recycling, etc. – that result in its retention in human applications thereby preventing its liberation into natural systems[2].

Once we have put in place a systemic approach to sustainability, toxicity and reputation issues may then be factored in as additional drivers in decision-making in the short term. For example, if we were to substitute organic materials purely on their relative persistence, we would be in conflict with known toxic effects in some instances. Say, for example, cellulose versus curare. Cellulose is extremely abundant in nature, forming the cell walls of plants, and is relatively durable otherwise plants would fall over! (It is interesting to think of wood as a 'persistent organic substance'!) On the other hand, curare is far less abundant and, as an extract from the bark of a tree, is used to poison arrow-heads by hunters endemic to the Rain Forests of South America. If we make a great deal of cellulose through fermentation processes, it will tend to accumulate in concentration owing to slow breakdown rates of the molecule. But is that our highest priority for action if nature can withstand high concentrations? The same principle also applies to synthetic polymers like polythene (polyethylene) that appear to us – today at least – to be inert. If the decision were between curare and cellulose, curare would become the obvious business priority for immediate action.

[2] For more on this, see the case study *Biodegradability versus Durability* in *Stepping Stones No.67 (January [ii] 2002)*. Also see the press article *A Material Dilemma* reproduced in *Stepping Stones No.55 (June 2001)*.

Streamlining Decision-making

The rationale for when to invoke the System Conditions, the Precautionary Principle, and other immediate priorities is simple, and can be handled through a basic hierarchy of decision-making:

Systemic Thinking and Backcasting. For strategic planning, backcasting from principles of sustainability is essential. This is because we have to define our goal (sustainability) if we are to head in the right direction. To do this, we need to be guided by first-order principles governing the sustainability of the planet we live upon.

'Accumulation', as referred to by System Conditions One, Two and Three, covers *increases in concentration* at the molecular level (System Conditions One and Two) and through direct physical effects (System Condition Three) as a result of accumulation. Chemical mechanisms (System Conditions One and Two) may cause chemical effects (such as the environmental effects of CFCs or toxicity arising from plutonium or endocrine disruption) or physical damage (such as that resulting from augmenting the greenhouse effect). When accumulation leads to violation of System Condition Three, we talk about physical encroachment, such as waste on growing garbage dumps.

Apply the Precautionary Principle to Areas of Uncertainty. If we don't know if we are breaching the System Conditions (accumulation is uncertain), we should invoke the Precautionary Principle. This should advise us to proceed cautiously – undertaking investigations or using alternative strategies – whilst measuring any potential accumulation.

'Forecasting' Immediate Business Priorities Based on 'Backcasted' Strategy. In making short-term decisions, and *provided we have developed a strategic plan through backcasting*, we can inform our choices with known toxicity data, inclusion on 'phase out' lists, or merely follow public opinion for competitive advantage. It is OK to forecast, for example by reacting to known toxicity data and to public perception where justified for business sustainability reasons, PROVIDED we are completely clear about:

The point of future sustainability from which we are backcasting;

The scientific realities of the substances we are thinking of transmaterialising;

How the <u>forecasting</u>-based choice represents a genuine next step from where we are today towards the defined goal of sustainability (derived by backcasting), and how it leads on to the next steps that will get us there; and

<u>Exactly</u> how the proposed solution presents a better option in the short term (on sustainability not merely PR grounds).

Within the systemic context of the System Conditions, it makes no sense to talk of 'no harmful effects'. We can, however, relate decision-making to the amount of a substance that nature can withstand. Water, as an example, is everywhere, and nature can withstand a lot of it (although water-toxicity is possible due to dilution effects). In this example, the concept of risk becomes irrelevant in any sensible assessment as these effects would occur at such high concentrations that there is little or no prospect of water 'accumulating in nature' through our action in many instances. This type of judgement, discriminating between different materials, would be for the judgement of the individual or company considering a specific production waste or emission.

Dangers arise when we get this hierarchy wrong, and are bounced into non-strategic decisions. We have to have the courage, backed up by robust scientific arguments, to defend our use of materials which, though unpopular in the media, may help us move towards sustainability.

Summing Up

Ecotoxicity and the Precautionary Principle are both important tools that have helped us significantly in getting to grips with the consequences of our historically cavalier and profligate use of chemicals. However, they are not necessarily the easiest tools to use in planning for sustainability, perhaps not the most relevant in all instances, and can lead us towards making non-strategic decisions if applied in isolation.

A more appropriate tool, that also helps us through the apparently conflicting pressures of the previous two approaches, is provided by the systems approach of the TNS Framework. In essence, this approach is founded upon *backcasting from principles of sustainability*, enabling decision-makers in business and other organisations to make strategic decisions regardless of information about known harmful effects of substances.