

**Submission on behalf of
Chemistry Innovation and the Chemical Industries Association
to the
House of Lords Science and Technology Select Committee**

Introduction

1) Chemistry Innovation is a publicly funded Knowledge Transfer Network (KTN) set up in 2006 to drive innovation performance across the UK chemistry-using industries. We facilitate innovation and knowledge transfer by providing unique networking opportunities that help to connect companies, universities, funding bodies, national, regional and devolved administrations and enable them to focus on a common agenda. The thrust of our activity is to provide the focus and stimulus to support product and process innovation that will deliver growth and sustainability through a coherent national strategy.

2) Chemistry Innovation is currently engaged in a portfolio of collaborative projects valued at over £40 million, representing a mix of industrial projects, CASE awards, TSB/EP SRC and EU funded projects, involving 150 organisations. We have formed strategic relationships with other National/European organisations involved in the delivery of innovation services to ensure a coherent approach with industry/academia in defining and funding the delivery of innovation projects. Evidence here is limited to our relevant experience and is focused on the chemistry-using industries which, with chemistry an underpinning science, covers sectors as diverse as pharmaceuticals, food and drink, materials and transport. One of Chemistry Innovation's core activities is to promote Sustainable Technologies and help UK industry become more innovative in their approach. It is imperative to describe the benefits of sustainability thinking to business. One of the best ways to accomplish this is with powerful examples and demonstrator projects.

3) The UK Chemical Industries Association (CIA) is the premier trade/employers' organisation in the UK chemical industry. It has a membership of 150 companies, many of which are international, operating from over 200 sites in the UK.

4) The chemical industry in the UK contributes over £5 billion annually to the country's balance of payments from a gross output of £50 billion. It accounts for 1.5 per cent of UK GDP, 11 per cent of manufacturing's gross value added, and employs nearly 200,000 highly skilled people directly as well as supporting several hundred thousand related jobs throughout the economy nationwide. The industry is global both in terms of markets and ownership, with over 65 per cent of CIA's membership being foreign "headquartered". Any significant imbalance in business operating environment between the UK and other locations can lead to the loss of UK output, trade and investment opportunities.

5) Responsible Care[®] is a self-imposed commitment by chemical companies worldwide under the auspices of the International Council of Chemical Associations (ICCA). It is designed to help companies continuously improve the health, safety and environmental performance of their operations and products. In the UK, where the Responsible Care[®] initiative has been in operation since 1989, compliance with the Guiding Principles of Responsible Care[®], and self-assessment of responsible care management systems, is mandatory for all CIA members. The CIA publishes information concerning the environmental, health and safety performance of its member companies on an annual basis in the Responsible Care[®] Indicators of Performance. In its new guiding principles and goals for sustainable development, launched on 6th July 2004, the Association has

committed, by 2010, to achieve a 25 per cent overall reduction in hazardous waste, a 20 per cent reduction in water use, and 11 per cent improvement in energy efficiency; together with a significant reduction in our environmental burden.¹

Better design and the use of materials

6) It is important that products are designed for disassembly and ease of recycling as we seek to protect our rapidly diminishing resources. Much is known of the impact of oil scarcity however many other vital materials are in dwindling supply. Many elemental metals are being exhausted by new technologies and will vanish forever without efficient recycling.² For example, indium metal is being used in increasing amounts in LCD flatscreen televisions, pushing up the price of the metal which is utilised for solar cell manufacture. The earth's supply of indium is predicted to run out as quickly as within 15 years time. Natural resources such as rubber and clean water are also increasingly stretched. Innovations in chemistry have a huge part to play in reducing waste in downstream sectors. The construction industry is an example of a sector where increased use of sustainable materials and design for ease of dismantling and separation could have a huge impact in reducing waste. New chemical technologies will be needed to achieve this such as new adhesives and high-performance insulating materials from sustainable sources.

7) Product developers are increasingly seeking to incorporate renewable materials into their goods but more research is needed into how the same product benefits can be delivered without a loss of competitiveness. For example personal care products may require substantial changes to base formulations to incorporate new materials. This is distinct from the increasing use of "natural" products, of which little is sometimes known of their health effects. Design and engineering graduates could have a profound effect on waste reduction and management in industry. This requires both adequate training, and commitment from industry. Resources such as the Ecodesign Pilot, developed by the Technical University of Vienna, provide both a framework for sustainable design, and many examples of its application in practice (www.ecodesign.at). Another example is the BASF ecohouse (<http://www.basf.co.uk/en/uk/house/?id=0..jjBny.bw24Sd>).

8) Chemistry Innovation is working closely with Bioscience for Business KTN on use of renewable feedstocks and with Resource Efficiency KTN on issues such as new catalysts for water treatment and methods to convert "waste" to feedstocks. Chemistry is a vital underpinning technology with huge scope for new innovations that address resource and sustainability issues. Chemistry Innovation launched an online Sustainable Technologies Roadmap in 2007 which provides a look into the future of the chemical and chemistry-using industries.³ It asks what industry needs to do to produce solutions that will help customers and society to be more sustainable, and what technologies can help. It will provide key decision makers in industry, academia and the UK Government with a clear picture of the challenges, opportunities, gaps and actions that need to be taken. Importantly it contains a wide variety of case studies exemplifying innovative solutions to sustainability issues.⁴ Cross sector communication of success stories provides stimulus for innovation in tackling such problems.

9) Recycling waste, or "cradle to cradle" thinking, can turn waste streams into important feedstocks for industry. This can be done in two ways; taking a waste stream from one process or industry and making it a feedstock for another, or by reusing materials within a single process or industry. An example of the first would be the development of integrated

¹ More details of this programme, including guiding principles and a goals brochure, can be found at http://www.cia.org.uk/newsite/downloads/Sustainable_Development_Brochure.pdf

² "Earth's natural wealth: an audit", *New Scientist*, 23 May 2007, issue 2605, page 34-41

³ <http://www.chemistryinnovation.co.uk/roadmap/sustainable/roadmap.asp>

⁴ <http://www.chemistryinnovation.co.uk/roadmap/sustainable/casestudies.asp?id=64>

biorefineries producing fuel and platform chemicals based on agricultural, commercial and domestic organic waste. An example of the second would be the recycling of tertiary packaging materials within the retail sector. In the big supermarkets, virtually all of the plastic over wrap used when palletising product for delivery to the supermarkets is recycled and reused. The barrier to the wider adoption of both processes is the variability of the waste streams, and the risk of contamination. We have yet to devise processes that can reliably produce raw materials of the required quality from the general waste streams. This is made more complicated by the tendency to increase the complexity of materials used in industry in order to gain other benefits in performance and environmental impact. For example, modern window glass is frequently coated to give additional benefits such as self-cleaning properties or control of solar gain. From the point of view of recycling this is a contaminated material which is extremely difficult and costly to clean up.

10) In the chemical industry itself there is both a long tradition of designing out waste through novel processing, and great potential for further development. The concepts of "atom efficiency" and "E-Factor", measures of how much of all the raw materials that are used in a manufacturing process end up in the final product, has been very influential.⁵ In-process waste minimisation has been practised in the chemical and related industries for more than two decades and a lot has been achieved already so that at least in the chemical sector most processes are optimised with respect to waste generation. The main driver for this was economics – it made business sense to do so.

11) Methods such as Lean Manufacturing, Six Sigma and similar approaches (such as Design for Manufacture – "easy to make" and Poke Yoke - "inadvertent mistake proof") have had a powerful influence in recent years. However, they are largely concerned with optimising an existing product and/or process. The larger opportunity is in redesigning a product and process completely to provide the user requirements in a different way. This "deep innovation" can reduce environmental impact by a much bigger factor. Lean manufacturing and six sigma have a proven track record in reducing waste, but they are not sufficient in their own right. It is more important to ensure that companies continue to strive to achieve the objectives rather than to seek to prescribe the perfect tool for achieving them.

12) Some sub-sectors have been better at process optimisation than others so there is still significant potential for improvement. However, it is not clear where and how the improvements can be made (i.e. are there any "low hanging fruit"?). The best way to reduce waste from a chemical process is to consider the amount that will be produced at the earliest possible stage in the design and development of the process. Unfortunately, the timescale for developing and proving novel processing techniques demands a lot of resources in time and personnel. In addition this period of rapid legislation changes and review make it a difficult area for manufacturers to commit to with any confidence.

13) The pharmaceutical industry is particularly active at the moment in reducing waste in the manufacture of pharmaceutical preparations because of increasing costs of raw materials, waste disposal, and protection for workers. They are particularly keen to increase the atom efficiency, and also to design out toxic and hazardous materials, whose management adds so much to their cost base. A strong interest in industrial biotechnology in the pharmaceutical, consumer chemical and specialty chemical sectors comes from the potential to reduce waste and improve efficiency as much as from the opportunity to produce novel materials. Chemistry Innovation is supporting BERR's Industrial Biotechnology Innovation Growth Team which is seeking to address issues surrounding adoption of biotechnology by the chemical industry.

14) For much of fine chemicals manufacture, reducing solvent use is where big gains can be made. Use of ionic liquids (which aren't volatile), supercritical fluids (highly

⁵ Roger A. Sheldon, Green Chem., 2007, 9, 1273–1283

compressed gases that can be recycled), process intensification (use of flow chemistry over batch) and solvent free processes all have the potential to greatly reduce waste. The sustainable chemical technologies roadmap developed by Chemistry Innovation has many examples of recently emerged and emerging technologies that have the potential to substantially reduce waste in a wide variety of sectors.

15) It is probably of greatest importance to re-think manufacturing processes on a life cycle basis and not looking just at processes themselves but feedstocks and products (i.e. can we start from different feedstocks, including using waste; can products be re-designed; do we need these particular products, etc). Shared responsibilities up and down supply chains should be encouraged (programmes such as the Chemical Industries Association's Responsible Care for example) and supported with simple to use tools for identifying "hot-spots" in a supply chain where shared action should be targeted with all members of the supply chain sharing the benefits of the improvements.

16) The key problem is that the ISO approved methods for life cycle analysis too slow, too complex and too costly for practical use in industry. As a result, a large number of "cutdown" methods have been developed but not standardised. For an organisation wanting to set out to use sustainable design to reduce environmental impact, it is an extremely confusing world. We urgently need internationally agreed methods for simple life cycle analysis suitable for use in the early stages of design and product development when multiple concepts are being evaluated. Similarly, we need more data in the public domain on the environmental impact of different materials. This is particularly true for new materials designed to improve sustainability. Defra has funded some work to enable high quality data on bio-derived materials to be made available to designers and manufacturers. Chemistry Innovation is involved in two projects, one European and one UK-based supported by EPSRC and the Carbon Trust, addressing life cycle analysis issues.

Business framework

17) If a waste reduction strategy made commercial sense, we can assume that the smart company would want to follow it. The barriers to them so doing include:

- a. *Awareness*—the benefits of resource efficiency are still not known to many companies, particularly the large number of SMEs. The stories, backed up by evidence, need to be told and retold.
- b. *Cost of analysis*—for many companies the cost of finding out whether there are financial gains for using resource efficiency is a substantial barrier, particularly if you have no previous successful experiences. Again this is particularly true for SMEs.
- c. *Lack of resources*—many companies are so thinly staffed that they lack the resources to undertake resource efficiency projects.
- d. *Lack of skills*—even with external support, many companies lack the skills to undertake resource efficiency studies, or to implement their findings.
- e. *Lack of fit with the capital investment cycle*—in many industry sectors capital investment follows a natural cycle. Ideas for resource efficiency need to either offer immediate and substantial benefits with low capital investment, or need to fit into a plan to refurbish, replace or extend capital equipment. With very long investment cycles in many industries, resource efficiency opportunities often occur when there is no real prospect of making the capital investment required.

If the company has carried out a proper analysis and the strategy does not make commercial sense, then they cannot be expected to follow it. Government has a role to shift the balance if it wishes companies to follow waste reduction strategies in areas which are not commercially viable. They can do this by regulation, or by fiscal policy which charges companies for their environmental impact. The chemical industry is global,

and has to compete with lower cost producers in the Far East and Eastern Europe. Generally, capital projects which implement waste reduction technologies do not meet the investment criteria applied to capacity expansion and new products, and in many cases are implemented for CSR reasons rather than economics.

18) There are examples where UK industry is at the leading edge of waste reduction, and examples where it lags significantly. Different countries have different regulatory environments, and this has a profound effect on the type of waste that industry focuses on. Regulatory environment, sector size and strength, relative costs of waste management, sector history, and whether the leading players are national or international all have an effect on waste management strategy in the sector.

19) Customers, regulations and standards can also be barriers to following a waste reduction strategy, particularly with respect to recycling. Customers may have specifications which explicitly or implicitly block the use of recycled material in a product. For example, it has been reported that the specification for vinyl flooring for government buildings means that recycled PVC cannot be used in these products. Such specifications may not have any scientific logic behind them, but can be incredibly difficult to change. International or national standards and regulation can have the same effect. The UK's wide interpretation of the definition of waste is posing a barrier to sustainable waste and resource management. The result of the interpretation in the UK is resulting in sites, whose by-product reuse or management has until recently (~2005) been regulated as part of their general Pollution Prevention and Control permit (and subject to BAT (Best Available Techniques) and BPEO (Best Practicable Environmental Option) considerations, being drawn into additional waste-specific regulation and its associated regulatory impact.

20) It is directing sites towards discontinuing previously agreed strategies to manage their process by-products sustainably (for example by burning in combined heat and power plant in place of virgin fossil fuel) towards sending such by-products, often over long distances, to the limited commercial incinerators available, or to landfill (if technically feasible) and buying in commercial (mainly fossil based) fuels in their place to power their boilers. In the following example, the UK Competent Authorities concluded that the material is waste:

“An installation produces an intermediate (which is used to make products) and methanol as part of a chemical process. The installation was designed with the specific intention to use the entirety of the methanol produced from this process as a fuel on site. The methanol stream does not require further processing prior to its use as a fuel. The process of manufacture and fuel combustion is regulated under and complies with IPPC requirements (all necessary measures are taken to achieve a high level of protection for the environment as a whole). The methanol is an output of production and, although it is not the primary motivation for the design of the manufacturing process, it is an output which is intended and which has an identified and certain end-use. In this case, the end-use is on-site use as a fuel. “

Materials produced as by-products of one industrial process that can be used by other industrial processes as raw materials may still be classified as waste for many years to come. This will mean that the twin goals of efficient use of resources and improved industrial competitiveness will remain unrealised. The chemical industry, along with a number of other sectors, has consistently lobbied for a more pragmatic interpretation of the definition of waste. The Chemical Industries Association are currently following closely the revision of the Waste Framework Directive and support the proposed Common Position text, which introduces a definition of by-product. We hope that this will help clarify the distinction between waste and product and therefore maximise efficient use of resources.

21) The use of weight targets to encourage recycling and waste minimisation do not always make sense, as for some waste it is volume that matters more than the weight (e.g. low density materials). It should also be noted that it is volume that matters in landfills, not weight. Also, some of the weight targets (e.g. in the WEEE Directive) are set at a ridiculously low level that they may have more of a negative than positive environmental impact, when transportation and processing are taken into account (i.e. economies of scale matter).

22) Weight targets do not take into account the full life cycle, and can have perverse or unintended consequences. For example, there has been a drive to reduce the weight of packaging, particularly for consumer goods. One solution to this problem has been to increase the sophistication and complexity of packaging materials, so that the same degree of protection can be afforded to the product, but at a much lower weight. This clearly reduces the amount of material which has to be manufactured and transported, but also makes it significantly more complicated to recycle materials. It is much easier to recycle a thick single polymer packaging film than it is to recycle a thin and light weight foil which may have used four separate layers of polymers to achieve the same level of protection and performance. For the best decision making there is no substitute for considering the full life cycle, but this remains difficult and costly to do in practice. In summary, targets should be set depending on the material and product, maybe using a combination of measures (weight, volume, toxicity etc.) rather than introducing a blanket approach for all.

23) Suppliers can influence manufacturers by demonstrating that using more sustainable materials, or using materials more sustainably, will improve their business. This might be through cutting their costs, being able to improve product functionality and performance, helping them meet regulatory obligations at minimum effort or minimum cost, or by enhancing customer profile. This requires very active interaction between customer and supplier. In some sectors, such as automotive with its Tier 1 and Tier 2 suppliers, supply chains are very closely linked together. In other sectors where materials may be used in a very wide range of applications, the supply chains have been less closely linked and there has been less involvement by suppliers in innovations of the customer. At the moment, for sectors like chemicals, it mostly happens when a customer has a driver to be more sustainable. For example, recently Ford in Europe wanted to reduce the waste generated by metal cutting machinery in the production of engines. Part of the problem were the lubricants and cutting oil used in the process, and by working closely with their lubricant supplier the supplier was able to develop a vegetable oil based lubricant which had both superior performance and superior environmental impact. As a result, Ford was able to realise significant savings in their engine plants. It is generally easier for a manufacturer to influence their suppliers than the other way round. REACH may encourage much closer interactions and exchange of information along supply chains, and could lead to opportunities for more sustainable use of chemicals. The application of mutual responsibility influences both parties to act in a more sustainable way such as shared responsibility for waste collection and recovery. Producers also have a large part to play educating consumers. The Chemical Industries Association's Responsible Care product stewardship is a voluntary industry programme that works on this aspect, trying to understand how customers use products and work with them to develop new products, which help them. For example: the development of a fabric treatment system to allow a downstream customer to complete several fabric finishing operations in one step, leading to significant water savings. Another successful example is the Voluntary Emissions Control Action programme (VECAP) established by the brominated flame retardant sector. Through VECAP, manufacturers and users of brominated flame retardants are working together to establish and share best practices on their handling to minimise emissions to the environment. In carpets manufacture for example, it resulted in a significant reduction in emissions along with substantial cost savings.