EA-Sustainable Development

ENVIRONMENT AGENCY

the NATURAL STEP

A Framework for Sustainability

2020 Vision Series No. 2

PVC and Sustainability

Dr Mark Everard, Director of Science, The Natural Step UK Office

Dr Mike T Monaghan, Researcher

Diana Ray, Facilitator

July 2000

Index

About This Document

2020 Vision is a process initiated by the Environment Agency to help create a vision of the kind of environment and sustainable future to which society aspires. The 2020 Vision Seminars are a collaborative venture between TNS (The Natural Step) and the Environment Agency. This report on PVC (polyvinyl chloride) is the second 2020 Vision report (the first tackled GMOs).

The public profile and interest, both in the media and in national and European government, about issues related to PVC have steadily increased in recent years. The issue of PVC is contentious. Mounting concerns amongst pressure groups, in the media and in Government (at national and European level) have meant that the PVC industry has had to act. Equally, there is evidence of decision-making outside of the PVC industry that is reactive and based neither on facts nor sustainable development considerations.

This document explores the place of PVC in a future sustainable world. The PVC Project, a co-ordination group comprising representatives of major retailers and the two UK PVC manufacturers, supported a research project to explore the sustainability issues of the PVC life-cycle using the principles of The Natural Step. The research project produced the report *PVC: An Evaluation Using The Natural Step Framework* (July 2000). In addition, the TNS principles were used at a 2020 Vision Seminar to build consensus within a group of invited experts about what would be necessary for PVC to be part of a sustainable future. The Environment Agency is a regulator of PVC during certain stages of its life-cycle and has a role in providing sound scientific advice as well as a duty to contribute to the achievement of sustainable development. The 2020 Vision process is described on the inside back cover of this document.

This document summarises the key issues and implications arising from the research and consensus-building processes.

For Further Information

Further information and contact points for the Environment Agency and The Natural Step can be found on the back cover of this report; a description of the 2020 Vision process also appears there.

This report is also available at The Natural Step's web site: www.naturalstep.org.uk. The detailed report *PVC: An Evaluation Using The Natural Step Framework* is available from The Natural Step, priced £15 to cover production and handling costs.

What is PVC?

PVC is a versatile plastic in widespread use across the world. It has many applications because of its combination of properties: it forms an excellent barrier to water and gases, has mechanical strength combined with light weight, is resistant to chemicals, is inherently non-combustible, and has electrical insulation properties.

The Manufacture of PVC

PVC is manufactured from two naturally-occurring raw materials: oil and salt. However, to convert it into a versatile material, PVC has to be combined with a wide range of additives including stabilisers, plasticisers, colouring agents, flame retardants, and fillers. In the majority of applications, PVC is used in a rigid form; it can also be made pliable by the addition of plasticisers. Around 30 per cent of PVC products contain plasticisers in proportions ranging from 10% to 46% of the final product. Current world-wide production of PVC exceeds 20 million tonnes; European production is approximately 5.5 million tonnes. (More detailed technical details about the manufacture and life cycle of PVC can be found in the document *PVC: An Evaluation Using The Natural Step Framework.*)

A Controversial Material

PVC is a controversial material and its continued use has been attacked, principally by Greenpeace who consider it should be phased out as soon as possible. (Greenpeace declined an invitation to the 2020 Vision seminar on the grounds that they were primarily campaigning against PVC and not seeking to "manage the problem".) The Greenpeace view, which is summarised here as it is supported by some businesses, is based on two primary concerns. The first relates to chlorinated organic molecules which Greenpeace consider to be not "inherently sustainable" since they inevitably enter waste streams and ultimately result in harm to nature and to human health. The second relates to the complex mixture of additives that are part of finished PVC applications, and which also enter the environment at end-of-life.

These concerns are already causing some companies to eliminate PVC. The Co-operative Bank, which was sadly unable to be represented at the 2020 Vision seminar but nevertheless submitted its views, is eliminating PVC from all of its sites and activities precisely because of concerns about the persistence and potential for bioaccumulation of chlorinated hydrocarbon compounds in nature at end-of-life. Issues of perception, whether based on science or not, are deeply relevant to both social and economic aspects of sustainability. Other companies such as Nike, Sony, Mattel and General Motors are also moving away from the use of PVC. Governments or government agencies in Sweden, Denmark and Germany have mooted restrictions on some formulations of the plastic. There is a limited amount of legislation against specific uses of PVC, or of additives to PVC, and also a number of voluntary agreements restricting their use. The PVC industry too has an incentive to demonstrate to its investors that it is managing this risk.

The PVC Life Cycle and the Sustainability Challenge

A great deal of progress has been made, both on a voluntary and legally-required basis, by the PVC manufacturing industry in recent years. Amongst the positive steps taken are increasing eco-efficiency on manufacturing sites, both through improved management as well as economic sense, and the development of two codes by the NCBS (National Centre for Business and Sustainability):[1]

- *Environmental Charter for UK PVC Manufacturers*;
- *Eco-efficiency Code of Practice for the Manufacture of PVC.*

Many life cycle analyses (LCAs) have been carried out upon various applications of PVC; probably more than for any other material. Inevitably they are of differing credibility, although the overall weight of them suggests that PVC is no more environmentally unacceptable or unsustainable than alternative materials (including "natural" ones) in the short to medium term. This reflects the general unsustainability of many aspects of modern society. However, relative degrees of sustainability compared with alternative materials are no cause for complacency for any sector of industry, its customers or its regulators.

The Sustainability Challenge

Sustainable development is about more than being "more green". It is about facing up to the challenge of a fast-changing world, where pressures on natural resources, the demands of a growing population, and the accumulation of wastes will inevitably impose restrictions upon how businesses operate. Sustainability considerations will increasingly impinge upon all sectors of society, and will inevitably continually challenge the acceptability of PVC products in terms of waste and processing implications, legislation, and health and safety concerns. There was a consensus at the 2020 Vision seminar that the challenge of making PVC fully sustainable is substantial. Bold and strategic action is therefore required by the PVC industry.

Using the Principles of The Natural Step

The TNS approach is systems-based, and reflects that all materials and processes must be considered within an overall scientific framework of sustainability. Both the research project and the consensus seminar used the objective framework of the System Conditions of TNS to assess the overall sustainability of the PVC. These System Conditions, explained in more detail in the next sections, are:

1. *Substances from the Earth's crust must not systematically increase in nature.*
2. *Substances produced by society must not systematically increase in nature.*
3. *The physical basis for the productivity and diversity of nature must not be systematically diminished.*
4. *We must be fair and efficient with respect to meeting human needs.*

[1]NCBS, previously NCBE (National Centre for Business and Ecology), can be contacted at: www.ncbe.co.uk

The following pages summarise key issues raised by evaluation of the PVC life cycle using the four System Conditions. This sustainability analysis highlights that the challenges lie not only in the production and use of PVC but across the entire life cycle of the plastic, particularly at end-of-use. One of the major problems is that materials, including PVC, are generally used only once and then thrown away into landfill sites, or else incinerated. "Once only" use is also wasteful of a valuable resource.

The science-based model of a sustainable world that TNS provides also serves as a framework for building consensus, going beyond the issue-based judgement of "good" and "bad" materials. The issue-driven approach can all too often lead to "knee jerk" decisions that may ultimately not be sustainable, and therefore offer no less risk. Ultimately, PVC and other materials must be judged on the "level playing field" of sustainability considerations alone.

System Condition 1

Substances from the Earth's crust must not systematically increase in nature.

Throughout the Earth's history, many substances have become "locked away" in the Earth's crust by biological processes, thus removing them from natural cycles and progressively purifying the atmosphere. In a sustainable society, fossil fuels, metals and other materials extracted from the Earth's crust cannot be released into nature at rates that exceed its capacity to lock them away again. Modern society breaches this System Condition in many ways, and the following breaches relate to the PVC life cycle.

Hydrocarbon Feedstocks

Hydrocarbon feedstocks comprise approximately half of the weight of PVC. Since most of the PVC content of final products ends up as waste material, deposited in landfill or incinerated, there is the potential for the accumulation of carbon derived from fossil reserves into nature, with all of the problems that it may cause (including climate change). Plasticisers are another significant hydrocarbon-based component of PVC products, and may comprise up to 50% of the weight of the finished plastic.

The main routes to sustainability would be developing alternative sources for feedstocks that do not depend upon fossil resources (for example biomass) and to recycle PVC products. Substantial increases in the recycling of waste PVC products would go a long way towards increasing their sustainability. It would also avert wastage of a valuable resource, and reduce related problems. At present, only about 3% of the PVC in the UK is recycled post-use. This offers considerable scope for improvement! Possibilities for increasing substantially upon this tiny level of recycling are matters not only for the PVC industry and other business sectors with high usage of PVC products, but also society as a whole.

Heavy Metals

The process of converting raw salt into chlorine can use mercury electrodes, resulting in emissions of mercury to the environment. While these have been much reduced in recent years, a complete elimination would be required to prevent the accumulation of mercury in nature. The raw plastic is thermally unstable so a wide range of stabilisers is used in finished PVC. These contain metallic compounds, many of which incorporate heavy metals, and these metals typically comprise around 2-3% of the weight of the finished plastic. Although the heavy metals are physically bonded into the PVC matrix and cannot be easily removed, they will tend to disperse into nature during production, manufacture and finishing, product life and, most notably, at end-of-life. Without comprehensive recycling, System Condition 1 is breached.

Recycling of wastes back into the process is carried out extensively within the factory. However, the problem of System Condition 1 compliance rests largely with the linear use of finished products. As a general principle, where additives inhibit recycling or the acceptability of recycled PVC, they should be eliminated or else the product itself becomes the pollution problem. Increased recycling of waste products is recommended in the short term, together with the use of metals more common in natural systems. Longer term, the development of a closed-loop manufacturing system (cyclic reuse of materials, rather than the linear *mine-use-dispose* ethos) is strongly advocated as a major step towards sustainability (considered in greater detail on pages 15 & 16 dealing with Closed Loop Manufacture).

Fillers

Up to 50% of the weight of some finished PVC products, such as floor coverings, window frames, electrical cables and similar products can be filler. Fillers are mainly inert materials such as calcium carbonate (chalk). Although there are few significant toxic effects during their manufacture, use or disposal, there is a potential for fillers to inhibit the recycling of PVC products. The UK PVC manufacturing industry does not see this as a problem in present formulations, although it acknowledges that awareness about all additives in the formulation is essential to ensure that obstacles or disincentives to recycling are avoided. Given that PVC can contain very high filler quantities, there is far greater scope for recycling than with comparable materials with a lower tolerance of impurities. There are therefore both risks and opportunities to be managed by the PVC industry as a component of its sustainable development.

Energy Usage

PVC manufacturing and processing plants use oil, natural gas, and electricity (mainly generated from fossil fuels). Ship, road and rail are also all used for the transport of feedstock, products and waste materials. The principal impacts of this energy consumption are in the direct or indirect generation of greenhouse gases and current energy use patterns are not a long-term sustainable option. Every sector of society will have to contribute to a major reduction in the consumption of fossil hydrocarbon fuels.

In manufacturing and processing plants, this is most immediately addressed by energy efficiency; replacing fossil fuels by sustainable, renewable sources is a longer term priority. Energy efficiency can be substantially improved through the installation of additional efficient local Combined Heat and Power (CHP), provided the CHP scheme does not result in the burning of more waste PVC on site. The two principal ways of reducing the breach of System Condition 1 in transport systems are reducing the amount of transport required and improving the efficiency of its use.

Other methods for improving energy efficiency should also be pursued vigorously within the industry. For example the use of novel energy-efficient refrigeration systems would be a further contribution. Rationalisation of the industry to have fewer large plants, developed to be closer to feedstock sources and final markets, is also an option that should be evaluated including social and economic implications. Finally, carbon sequestration schemes[2] are likely to be essential, at least in the medium term, if a carbon balance is to be achieved by the industry.

All such measures have to be addressed within a wider framework of sustainability rather than tackled on a single-issue basis, since substantive increases in the quantity of PVC recycling might best be effected, for example, by more smaller-scale plants. Whatever the plant strategy, improved utilisation of transport should be given high priority as a means for making a significant contribution to energy saving. Selection of the optimum mode of transport may also make a significant contribution to sustainable development.

[2] "Carbon sequestration" is the process of immobilising carbon emissions that might otherwise accumulate in the atmosphere with unpredictable consequences. The most common method is to plant trees in long-term plantations, relying on the photosynthetic activity of these trees to "lock up" carbon dioxide into the solid form of wood. Other technical approaches are being explored and developed.

System Condition 2

> ***Substances produced by society must not systematically increase in nature.***
>
> Nature has evolved to process the diversity of chemicals in the environment. However, industrialised society has created - both deliberately and as by-products - a wide range of novel chemicals, and has also changed the forms of naturally-occurring substances. In a sustainable society, chemical substances cannot be produced at a faster pace than they can be broken down and reintegrated into natural cycles. The systematic accumulation of substances produced by society can have unforeseen consequences.

PVC Products, Chlorine, Dioxins, Furans and other Organochlorine Compounds

PVC is a man-made material, most of which currently ends up in landfill or incinerators. PVC products are generally inert. However, over the longer term, an accumulation of less inert substances may result from physical and chemical breakdown in use, leaching or migration of additives, and accumulation in waste streams. This breaches System Condition 2. It is also a waste of a valuable resource (System Condition 4).

We discussed the production of chlorine from salt under System Condition 1. Of greater concern than the source of chlorine itself, are the implications "downstream" of the chlorinated wastes. The generation of organochlorine substances through incineration, either controlled or uncontrolled, is also a substantive cause for concern where these are not fully removed from emissions to air, water and/or land. Greenpeace believes PVC to be inherently unsustainable precisely because if chlorine goes into a process then chlorine must come out and, where the loop is not fully closed or otherwise controlled, dioxins and other organochlorine substances are the likely products of incautious disposal. The PVC industry refutes this claim, but the principle of eliminating problematic emissions across the whole life cycle of the plastic remains a priority to be addressed.

The production of dioxins (one of the most toxic and persistent group of substances known) and furans during manufacture and waste incineration has been among the most controversial aspects of the PVC industry. Whilst releases of dioxins directly from the PVC industry may now be minor, any contribution to increasing levels of persistent and bioaccumulative substances in nature is not sustainable. The uncontrolled burning of PVC products, or the non-recovery of chlorinated compounds from controlled incineration, is also of substantial concern. Until better measures exist to facilitate the reuse of PVC, this source of dioxins, furans and other organochlorine compounds is likely to remain and to be of significant concern to the public.

Long term, chlorinated organic substances from industry sources must be fully eliminated if the industry is to be considered sustainable. Dioxin emissions from transport and fossil fuels must also be addressed through transport and energy-efficiency schemes, although it is recognised that this is a problem that is society-wide and not specific to PVC manufacturers and users. Tackling the emission of dioxins from end-of-life products can only be achieved through more detailed work on "closing the loop" on PVC (considered in greater detail on pages 15 & 16 dealing with Closed Loop Manufacture).

VCM and EDC

VCM (Vinyl Chloride Monomer) and EDC (Ethylene Dichloride) are intermediate products formed during the manufacturing process for PVC. Modern processes have been changed such that the emissions are currently at a level that is well below any predicted trigger level for adverse health effects. During normal operation, the emissions are no longer hazardous to operatives or neighbours of the plant. However, there is always the possibility of a substantial release arising from an accident within a plant or during the inter-plant transportation process. The goal of sustainability will be met when no VCM or EDC, or any of their breakdown products (potentially including persistent and bioaccumulative substances) accumulate in nature.

Refrigerants and Fire Fighting Chemicals

Refrigerant and fire-fighting chemicals used in PVC manufacture present sustainability challenges as many are ozone-depleting or can accumulate in nature with unpredictable consequences. At present, these issues have to be balanced against safety considerations but, long term, the goal of full sustainability can only be met when there is no breach of System Condition 2 through the release of ozone-depleting, global-warming, and other persistent, unnatural substances into nature.

Conversion of the refrigeration plants to non-ozone-depleting substances is technically possible. Establishing targets for eliminating fugitive emissions of HCFCs during the transition period should be introduced. New, lower-energy refrigeration processes are becoming available and should be assessed. There may be other ways of providing cooling services that are not currently in use by the industry, and manufacturing processes that do not require refrigeration may need to be investigated.

Plasticisers

Many plasticisers are in use in PVC products, with phthalates being the most common. The main concerns about these products are their possible carcinogenic and other biological effects. There is no wide consensus on the details of their environmental persistence, although they are known to accumulate in invertebrates and to stimulate the formation of cancers in rats. The capacity of phthalates to disrupt endocrine (hormone) systems has been hotly disputed, and there remains a lack of agreement as to the magnitude of this effect. However, phthalates are recognised as being readily biodegradable under aerobic conditions, and do not tend to accumulate in the food chains. In the absence of a clear consensus, System Condition 2 advises the management of all releases across the whole product life cycle such that the types and quantities of plasticisers allowed to enter nature can be broken down and reintegrated by natural processes, and that no toxic effects ensue. Given that these levels are not yet known, the Precautionary Principle would suggest that incautious use and emissions are not ultimately sustainable.

Further study of phthalates, and evaluation of alternative plasticisers, will be necessary to help demonstrate progress towards sustainability. In the absence of a full sustainability analysis, there should be no starting assumption that the alternatives to a known or suspected problematic substance are any more sustainable. Recycling waste PVC products so as to prevent the leaching of the products would be a more significant step in the interim (see pages 15 & 16).

Stabilisers

As already noted in the consideration of stabilisers under System Condition 1, a wide range of metallic substances is used in PVC products as stabilisers. The metals themselves predominantly contravene System Condition 1, although the organometallic compounds used as stabilisers, and also their long-term potential for recombination in landfill and elsewhere, constitute a breach of System Condition 2. In a sustainable future, all such organometals that can accumulate in nature, directly or as breakdown products, would be phased out or used only in ways that do not result in their accumulation in nature. This assessment would have to be made across the whole life cycle, including end-of-life.

"Closing the loop" to prevent linear usage of metal-containing PVC products end-of-life is fundamental to eliminating accumulation in nature. Where accumulation occurs and adverse effects are observed, migration to metals more common in nature and/or to other potentially safer compounds may be a viable alternative short-term whilst long-term sustainable solutions are sought.

System Condition 3

The physical basis for the productivity and diversity of nature must not systematically be diminished.

The sustainable cyclic processes of nature, upon which life on earth depends, are substantially driven by green cells and powered by net inputs of solar radiation. Therefore, in a sustainable society, the productive surfaces of nature, including their biological diversity and the processes that ecosystems perform, are not diminished in quality or quantity. We must not harvest more from nature than can be re-created and renewed, nor seriously compromise the processes performed by natural systems.

Raw Materials

The production, refining and transport of the substantial quantities of fossil-based hydrocarbons used by the PVC industry, as feedstocks or energy sources, inevitably damage or destroy habitats. If a future PVC industry continues to use fossil hydrocarbons on the same scale, this element of unsustainability will persist. The usage of hydrocarbon substances derived from plant matter may be no more sustainable, owing to the possible negative impact of the land take and biodiversity loss from monoculture farming for biomass feedstock. Potential transport implications would also need to be addressed within a further detailed sustainability analysis.

Manufacturing Plants

PVC manufacturing and processing plants, and other chemical plants, occupy land. In the past, this has contributed to incremental loss of habitat, productivity and biodiversity. The trend in Europe and the USA now is one of rationalisation of plant and release of land. The pattern in the Far East, and probably elsewhere in the world, is the reverse.

The rationalisation of plants will potentially reduce the area of land taken per unit of production. Any future expansion of the industry on to new sites would need to include an assessment of this impact, and options for minimisation and mitigation. For example, use of "brownfield" sites for future development will contribute to increased compliance with System Condition 3. Within large plants, there are often areas of land in which biodiversity can be encouraged. This should be pursued whenever possible not merely as a matter of good practice, but also to go some way towards offsetting the overall habitat "take" of the industry.

Transport

Considerable transport is associated with the delivery of raw materials, manufacture, processing, distribution, utilisation and disposal of PVC products. Transport infrastructure, especially road, covers large areas of land and destroys natural habitat. The PVC industry contributes, albeit to a limited extent, to this land loss.

Rationalisation of the use of transport so as to minimise distances would be a significant contribution towards sustainability. So too would optimisation of the transport mode, for example wherever possible switching from road to rail or ship, which have less overall negative impact on the environment.

In practice, this rationalisation has to be balanced with risks to health and the environment from accidental loss. This illustrates the need to address sustainable development within a holistic framework that takes account of human and environmental as well as economic factors.

Waste Disposal

Many of the waste PVC products in the foreseeable future will be deposited in landfill sites or else incinerated. Although many landfill sites are already degraded areas such as quarries, this waste nevertheless contributes to the loss of land area and quality arising from waste disposal in the long term. It would appear to be inevitable that a proportion of waste PVC products will continue to go to landfill in the medium term, because there are currently no sustainable means of disposal. This dependence is exacerbated by waste streams containing mixtures of materials from which it is very difficult to separate the PVC.

Whether a strictly limited amount of PVC can be permitted to go to landfill and still be considered sustainable is a matter for further analysis. In the absence of consensus on this principle, and the amounts of waste material that might be involved, the target of "zero waste" is the most helpful objective in determining the path of sustainability. Reducing the amount of waste produced by increasing the level of reuse and recycling will be the most effective way of tackling this problem.

Water Use

Substantial quantities of water are used in the manufacturing and processing of PVC. (The extent to which water use is minimised and recycling already takes place has not been evaluated during this study.) Systems to reduce and recycle water will contribute to tackling the worldwide and growing problem of water shortage.

Mining of Stabilisers/Fillers

Mining inevitably destroys habitats, either directly or indirectly, and should therefore be managed at the minimum level consistent with meeting human needs. Although the relative quantities of minerals used by the PVC industry are not large, they nevertheless make a contribution to this habitat loss and therefore breach System Condition 3. Reduction of quantity or substitution of stabilisers with less damaging alternatives and greater use of recycling will lessen this breach.

General Notes about Habitat Loss

Even with all the anticipated improvements in efficiency, recycling, changed transport modes, etc, the activities of the industry may cause some loss or damage to habitats in the medium term. The loss of natural productivity is a serious issue world-wide, as nature's life-support services ultimately support all life, provide the primary resource for business, and contribute to "quality of life". Since loss of natural habitats, and the biodiversity and productivity that they support, is often a matter of "death by a thousand cuts" - small incremental damages resulting in substantial cumulative loss - there is a need to address habitat in all development decisions across the PVC life cycle.

Loss of biodiversity may be the most serious problem facing the world in this millennium. Funding compensatory habitat restoration schemes, either as mitigation or by restoration of habitat previously taken, could eliminate the net impact of incremental damage. Such habitat restoration schemes seek to mitigate the loss of natural productive habitats that occurs through the construction of manufacturing plant or other human infrastructure. By offsetting harm to ecosystems, and ideally restoring degraded habitat to increase productivity and biodiversity overall, the "permission to operate" of the company is increased both by improving the life-support services that make business possible as well as by building reputation.

System Condition 4

We must be fair and efficient in meeting basic human needs.

Society, and business within it, relies not only on natural resources but also human resources. In a sustainable society, social and economic relations would be organised in such a way as to maximise the chances of meeting System Conditions 1 to 3. Basic human needs would be met with the most resource-efficient methods possible, including equitable resource utilisation and distribution.

Responsibility

Business sustainability is about far more than improving economic and environmental performance. A genuine commitment to sustainable development acknowledges responsibilities to employees and the communities in which an enterprise is located, to business partners, suppliers, selected NGOs (non-government organisations) as well as to the environment and future generations. Corporate reputation and its "license to operate" around the world depends upon meeting these wider responsibilities while competing effectively. Good business is, by its very nature, socially as well as environmentally responsible business.

Equity

People everywhere should be treated in an even-handed fair manner - in ways that respect their basic rights - since compromising peoples' rights in the pursuit of profit is not merely unethical but ultimately unsustainable. This raises social justice issues, including procurement policies, exposure of people to pollutants, an equitable share of risks and benefits, and standards that apply equally across the globe. The extraction of raw materials, manufacture, supply, use and disposal of PVC products have regional and international implications. Multinationals have often been accused, sometimes justifiably, with accruing inequitable proportions of profit from the regions in which they operate and the people that their activities affect. The same accusations have also been levelled at procurement strategies that some might view as exploitative. The PVC industry should ensure that its procurement, manufacturing and other procedures do not use human resources without appropriate recompense. Priorities with regard to employment, supply chain management, community welfare and fair trade should be examined.

PVC plants are already being constructed in developing countries, and the same high standards of performance are required of operators who are subsidiaries of major European and American companies. The same principle should also apply to other major players in the PVC life cycle. Countering the negative effects of globalisation will involve effective and inclusive communication with all stakeholders, local decision-making and sourcing, community involvement and education

Efficiency

Various materials permit human needs to be met with differing degrees of efficiency. The more efficient the material or process, the more effectively needs can be met and the greater the consequent capacity to meet these needs across a growing global population. Wastage is therefore a primary breach of System Condition 4. As we have observed previously, only some 3% of post-use PVC is recycled in the UK at the present time.

The PVC industry considers its products make a significant net positive contribution to helping people meet their needs. The plastic is relatively cheap, lightweight, strong, and adaptable to many applications. Its light weight and its thermal properties are beneficial in buildings, and the wide use of PVC in irrigation and roofing benefits users in the developing world. PVC is also the best material so far discovered for many medical applications. However, it has been questioned in the media whether excessive packaging and other short-life applications for which recycling may be difficult are a prudent use of resources. On the other hand, PVC has unique barrier properties, is non-tainting and may reduce food wastage.
All of these factors have to be weighted together, and fully sustainable solutions sought long-term. It is also important to consider the life-cycle sustainability of PVC on a specific application-by-application basis.

Learning

Sustainable development depends upon an understanding of the mechanics of the natural world, and how the essential life-support systems of this world ultimately make life and business possible. When natural systems are damaged, all of society, including businesses, is harmed and its activities are constrained. This fundamental understanding is not currently evident in the PVC industry nor, it has to be said, in many other places in society. It is therefore essential to address sustainable development not merely as a technical issue but as a learning exercise in which all participants understand the purpose for this commitment. The raising of awareness of employees across the PVC life cycle would indicate a commitment to addressing sustainable development as a matter of organisational and cultural change, not merely of reacting to a threat.

The industry should continue to ensure that, in helping people meet their needs, it does so in ways that eliminate risks. Ultimately, it will be the consumer who decides on the balance of risk involved in the use of PVC products. A precautionary approach should therefore be taken to all risks posed to people everywhere in the manufacture, use and disposal of PVC.

Closed Loop Manufacturing

The Industrial Revolution, which set in train the basis of how business and industrialised society operates, occurred when world population was much lower and natural resources more abundant. The linear use pattern - *mine-use-dispose* - of resources has led to pollution, resource depletion, exploitation and other sustainability problems on a staggering scale. In contrast, the sustainable processes evolved by nature are all cyclic, resulting in no net waste - the outputs from one process form the inputs of others. A major part of the achievement of sustainability will be the realisation of cyclic resource use patterns across society, and the release into nature only of substances that can be broken down at rates that can be reintegrated by natural processes.

Facing the Challenges

Cracking the sustainability challenge for PVC will entail addressing the whole life cycle of the plastic, and not merely what occurs within the confines of the factory gates. The challenges entailed in "closing the loop" on PVC products in practice, preventing their linear disposal in landfill or incinerators, are formidable. Some are technological; others social. For example, effective recycling relies equally upon efficient technology, collection and sorting infrastructure, the willing participation of customers and the public, and the right economic climate. It is necessary to engage with all stakeholders involved in the PVC life cycle, and to address the challenges posed by PVC within a wider strategic approach to resource use and waste management in the UK.

If we use the materials that we manufacture again and again, we place lower demands upon primary resources and transportation from their point of origin, and we ensure that end-of-life waste does not build up. That way, plasticisers, stabilisers, hydrocarbons and other constituents cannot accumulate in nature. Closed loop manufacture is an ideal - remote for PVC but also probably for many other materials in use by society - but is also ultimately a potentially sustainable option. It goes without saying that recycling should always be to the highest quality possible.

As a thermoplastic, PVC can be recycled many times without substantial loss of integrity and structure. Nevertheless, the difficulties of implementing effective collection and sorting should not be over-estimated. If efficient re-manufacturing can be demonstrated as a practical rather than merely theoretical possibility, the fact that the plastic need not be "down-cycled" into lower value products at each cycle will be a helpful step towards cyclic use and a factor in the favour of the plastic.

The Feasibility of Closing the Loop on PVC

PVC has a number of qualities that may aid recyclability. Recycling is theoretically feasible through physical, chemical (re-melting), feedstock recovery and other closed loops. Indeed, many such recycling loops are in operation in Germany (the windows industry), in the UK (packaging recycling), in Denmark (cable recycling), within manufacturing plants, and on a pilot scale for other applications. It is also possible in theory to recycle PVC into products of not significantly lesser quality. The UK PVC industry claims to be able to reformulate PVC to suit many uses, including the facilitation of recyclability. (We have considered previously the importance of formulations that do not inhibit recycling.)

The chemical components (specifically the chlorine content) of PVC can also aid automatic identification of the plastic (using a technique known as X-ray fluorescence) and therefore the consequent automation of sorting of PVC from waste streams. One in three local authorities in the UK now have schemes to collect plastics for reuse, so elements of the infrastructure are already in place. The Government has recently launched its Waste Strategy 2000 further to drive forward this process.

However, in practice, the gap between theory and practice is huge. The tiny level of actual recycling in the UK will remain so without further local, national and international incentives and also without greater pressure from the industry itself. Collection remains the key issue. All sectors of society, as well as the behaviour of individuals, are crucial to this. In order to deliver the necessary infrastructure - structural, social, behavioural, economic - to deliver a closed loop manufacturing system across the whole PVC life cycle, it is necessary for all partners to share both the "pain" and the benefits of its development. Globalisation also artificially depresses the true environmental and social costs of producing virgin PVC, dissuading investment in recycling. The Polluter Pays Principle may not be well observed by the current economic system, which may need to be redressed. The question has to be posed as to whether it is feasible to develop a closed system for PVC, and further exploration and implementation is a priority for all.

There remain doubts within the PVC industry about whether higher levels of recycling (approaching 100%) are better from a sustainability point of view than the optimum levels indicated by several eco-efficiency evaluations. These doubts are based on the current higher economic costs of recycled versus virgin PVC, and the disbenefits of transporting waste material (the transport of waste materials is now reported to account for up to 15% of all transport in Europe). On the basis of today's market costs, it is possible to argue an economic balance point between the costs of recycling and the energy efficiency gains of heat recovery from incinerated wastes. However, from the sustainability perspective, the cyclic use of materials is ultimately a requirement to prevent the accumulation of wastes, to improve efficiency and to pre-empt inevitable changes in the market place once environmental and social costs are fully accounted for in regulations and market prices. We can also assume that a more sustainable transport infrastructure will be developed, and part of the solution may also include reprocessing facilities local to the source, utilising renewable energy for cleaning, separation and recycling.

Sustainable transport and recycling infrastructures need to be developed in parallel with increases in recycling levels for all materials, and ideally with parallel economic changes. The absence of such an infrastructure should not prevent the PVC industry and heavy users of the plastic from taking a proactive stance, and bringing their collective influence to bear upon decision-makers across relevant sectors of society.

Above all it is important that the challenges of sustainable development for PVC, as indeed for other materials, are tackled by backcasting - as strategic issues with sustainability as a clear end-point - rather than as eco-efficiency challenges aimed merely at optimising economic sustainability within today's transient limits of acceptability.

PVC also has many long-life applications (including pipes, cables, window frames and other building applications), so much of the PVC manufactured in recent years is still in use in applications with lives of anything up to 50 years, or perhaps even well beyond this. Therefore, the amount of used PVC in the coming years that may potentially be returned for recycling will be far greater than today. This surely represents a substantial business opportunity to drive forward the efficient and effective recycling of PVC, with all of the collection and sorting infrastructure that this would entail.

Sustainability Challenges for the PVC Industry

At present, PVC-production and usage, particularly at end-of-life, breaches the System Conditions of TNS in a number of significant ways. It is therefore clearly unsustainable taking into account current methods of manufacture, conversion, use and disposal, and this despite the considerable eco-efficiency improvements that have been made over recent years. The challenge of achieving sustainability should not be seen solely as a longer-term issue. Global and national commitments to reductions in greenhouse gas emissions, legislation concerning packaging waste, and public concerns about the fate of PVC in incinerators all indicate the accelerating trend of restrictions on PVC, acting like a "funnel" constraining industry's room for manoeuvre. This in turn signals the business advantages of addressing sustainable development as a business priority.

Based on the System Condition analysis, five key challenges emerge for the PVC industry. If accepted and addressed proactively, they would mark a major shift towards sustainability and should yield clear business benefits.

CHALLENGE No. 1

The industry should commit itself long-term to becoming carbon-neutral.

CHALLENGE No. 2

The industry should commit itself long-term to a closed-loop system of PVC waste management.

CHALLENGE No. 3

The industry should commit itself long-term to ensuring that releases of persistent organic compounds from the whole life cycle do not result in systematic increases in concentration in nature.

CHALLENGE No. 4

The industry should review the use of all additives consistent with attaining full sustainability, and especially commit to phasing out long term substances that can accumulate in nature or where there is doubt regarding toxic effects.

CHALLENGE No. 5

The industry should commit to the raising of awareness about sustainable development across the industry, and the inclusion of all participants in its achievement.

The 2020 Vision Seminar and its Key Outcomes

2020 Vision, a collaboration between The Natural Step in the UK and the Environment Agency, is a process for sharing information and seeking consensus on contentious issues, moving the debate forwards in the light of a collective enquiry into the place of that issue in a future sustainable world. The 2020 Vision process uses The Natural Step framework as a systems thinking approach to structure this debate. **2020 Vision Seminars** engage an invited expert audience in a consensus-building process primarily focused on ascertaining Points of Agreement and identifying Next Steps to take forward sustainability challenges. The **2020 Vision Series** of publications disseminates the outcomes of these seminars, together with a summary of relevant research undertaken by The Natural Step.

Points of Agreement

A range of points of agreement evolved during the 2020 Vision Seminar on PVC. Key points included:

- The chemical constituents of PVC products raise particular concerns for health and the environment. The PVC industry acknowledges the need for change, recognises that it must act, and also accepts the sustainability principles and the need to address the "five challenges" in this sustainability evaluation, which will drive innovation towards sustainability.

- If PVC is to become fully sustainable, waste must be eliminated through cyclic use. However, the PVC industry can not achieve the end-goal of a sustainable PVC life cycle in isolation, but needs to become sustainable within a sustainable society. It needs to engage society, other sectors of industry and Government, NGOs and retailers, its investors - all stakeholders - and to become a leading partner in its achievement.

- "Knee-jerk" reactions against PVC (or other materials) in favour of alternatives may not represent sustainable development, since alternative materials cannot automatically be assumed to be any more sustainable. Ultimately, equal scrutiny should be given to the sustainability implications of all plastics and other materials used by society if we are truly to be tackling sustainable development, creating a "level playing field" and a route map to a sustainable future.

Next Steps

2020 Vision Seminar delegates also agreed upon next steps to take the debate forward in the light of the issues raised. Key points include:

- Delegates agreed to address the "five challenges", and it is for the PVC industry to engage its senior management on these and other issues raised. It is also for the wider UK and European PVC industry to read and respond to this report, and also to take the outcomes to the global PVC industry (including suppliers of additives as well as PVC converters) via various trade organisations and conferences.

- The PVC industry should take a leadership role in promoting recycling. This may include educating users in the retail and construction sectors to promote sorting, engaging other key players across society, and learning from examples of best practice in other countries.

- To engage the Environment Agency and other relevant regulators in the process of The Natural Step.

- For the industry to advertise its commitment to a wide range of stakeholders, and also to reengage with NGOs, collectively to overcome obstacles posed by consumer expectations and habits, economic barriers, the inadequacies of education and other societal behaviours.

Consensus-building is a *process* and not an end-point. The views and needs of a wider range of stakeholders must be tapped as a basis for assessing and managing the production, use and reuse of PVC in a sustainable way. The PVC industry identifies the need for it to be a leading partner in addressing these ultimately unavoidable sustainability challenges. As part of its achievement, there is a need to further develop and communicate the "whole systems" view, not just a traditional environmental/eco-efficiency focus, and also explicitly to include consideration of the required changes in the economic environment that would drive forward a more sustainable PVC life cycle. It is also important to note that the ideas and findings in this document include significant reservations, as well as a wide range of benefits - social and economic - associated with PVC.

There was consensus that the PVC industry needs to become sustainable within a sustainable society. To achieve this it needs to "own" the problem, to engage stakeholders right across society to achieve it, and to influence government to drive forward the changes necessary to achieve sustainability. Engaging with the UK government, the Environment Agency and other regulators of aspects of the PVC life cycle, and in particular engaging them in the sustainability-focused TNS process, was seen as a priority.

Who Was Involved in the 2020 Vision Seminar?

The following thirty-six people took part in 2020 Vision Seminar upon which this report is based.

From the Natural Step
Jonathon Porritt, Chairman TNS UK
Dr Mark Everard, Director of Science
Diana Ray, TNS Facilitator
David Cook, Chief Executive
Maggie-Jo St.John, Development Co-ordinator
Anna Kennedy, TNS Gloucestershire Project
Mike Monaghan, TNS Researcher

From the Environment Agency
Charlie Corbishley, Policy Advisor
Liz Greenland, Science & Data Exploitation Manager
Ian Taylor, Environmental Protection National Service
Roy Watkinson, Hazardous Waste Policy Manager
Louise Wolfendon, Senior Environmental Scientist

Other Invited Guests
John Trampleasure, Director of Fundraising & Development, Forum for the Future
Jane Anderson, Building Research Establishment
Heidi Bager, Norsk Hydro ASA (Norway)
John Speirs, Managing Director, Norsk Hydro (UK) Ltd
Erik Bichard, Director, National Centre for Business and Ecology
Duncan Bowdler, Trade Liaison Manager, Co-operative Wholesale Society
Rolf Buehl, Environmental Affairs Manager, EVC (Brussels)
Roger Mottram, UK External Affairs Manager, EVC UK Ltd
Ian Stockdale, Corporate UK SHE Manager, EVC UK Ltd
Nigel Waghorn, UK Engineering Centre Manager, EVC UK Ltd
Dr David Cadogan, Director, ECPI
Sue Cosgrove, Tesco Stores Ltd
Peter Donnelly, Regulatory Affairs Manager, Akcros Chemicals
Malcolm Gall, Quality Assurance Manager, Hydro Polymers Ltd
Brian Jones, HR & Systems Manager, Hydro Polymers Ltd
Jason Leadbitter, Environmental & Regulatory Affairs Manager, Hydro Polymers Ltd
Jan-Chris Hullegie, Material Resource Coordinator, Nike Europe (Holland)
Annie Peirson-Hills, European Environmental Affairs Manager, Nike Europe (Holland)
Paul Ovstedal, Technical Director, Waitrose
Paul Riley, Network Team Manager, Carillion plc
Leonie Smith, Trading Law & Technical, Tesco Stores Ltd
Ian Taylor, Environment Manager, ICI
Andy Wales, Sustainability Manager Europe/Asia, Interface Europe
Bob Mantle, Process and Materials Manager, Interface Europe

The following people were unable to attend the seminar, but have been corresponding members reviewing outputs from the seminar.

From The Natural Step
Professor Stephen Martin, Director of Learning
Dr Karl-Henrick Robért, Chair, TNS international office

From the Environment Agency
Stefan Carlyle, Head of SATIS
Nina Smith, Sustainable Development Secretary
Ceri Davies, Policy Manager
Geoff Brighty, Environmental Toxicology Manager

Other Invited Participants
Paul Bowtell, Environment Manager, Asda Stores Ltd
John R Svalander, Consultant Industrial Affairs, ECVM (Brussels)
Chris March, Dean of the Faculty of the Environment, University of Salford
Paul Monaghan, Ecology Unit Manager, The Co-operative Bank
Jayn Harding, Deputy Environmental Manager, Sainsbury's
Bernard Walsh, DETR
Jane Stratford, DETR
Cathy Cameron, DETR
Suzy Edwards, Building Research Establishment (BRE)
John Longworth , Trading Law & Technical Director, Tesco Stores Ltd
Professor John Krebs, Joint Food Safety & Standards Group
Richard Macrory, University College London

About the 2020 Series

The 2020 Vision Series of publications aims to provide information about a range of contentious issues, many of which have featured in the media. The Natural Step office in the UK, together with SATIS (the Scientific and Technical Information Service of the Environment Agency), runs a series of 2020 Vision Seminars. These seminars involve invited participants in the sharing of information and debate about the place of specific contentious issues in a future more sustainable world. This 2020 Vision Series publication reports on the sustainability analysis using the System Conditions of TNS, as well as the outcomes of the 2020 Vision Seminar on PVC. This summary document is also available at The Natural Step's UK web site: http:\\www.naturalstep.org.uk. (You can also find the 2020 Vision Series No.1 document on GMOs on the same web site.) The detailed report PVC: An Evaluation Using The Natural Step Framework is also available from The Natural Step office in the UK, priced £15 to cover production and handling costs, using the contact details on the back of this document.

About the Environment Agency

The Environment Agency has wide-ranging powers and duties relating to water management, environmental protection and pollution control across England and Wales. Its principal aim is to exercise them so as to contribute to sustainable development. The Agency therefore has strong interests in the application of science to decision-making - both its own and that of other sectors of society - as an important part of its contribution towards the achievement of sustainable development. The 2020 Vision process started internally within the Agency as a mechanism to envisage the kind of environment that the Agency wished to work towards. The 2020 Vision series of seminars and publications has stemmed from this aspiration, and provides an expert analysis of the place that a range of contentious issues occupy in a future sustainable world.

About The Natural Step

The Natural Step (TNS) framework is a science-based learning and decision-making programme aimed at helping organisations to understand and apply the concept of sustainable development. It was developed in Sweden in the late 1980s. The Natural Step office in the UK has been operating as a charity, led by the well-known environmentalist Jonathon Porritt, since the beginning of 1997. It has already been successful in helping a range of large companies[3] address sustainable development as a strategic issue. The science-based model of a sustainable world, which lies at the heart of TNS, can also be used as an "intellectual round table" around which to address the various social, environmental and economic aspects of contentious issues. Together with a range of other specialist tools, it also provides an "intellectual round table" for the building of consensus about the place of these issues in a future more sustainable world. The Natural Step office in the UK, which is supported by the Environment Agency, is a partner of the Agency in the 2020 Vision series of seminars and publications.

[3] The Natural Step UK Business Network currently comprises ten companies: Air BP, Carillion, the Co-operative Bank, DuPont, Interface, Sainsbury's, Sun Microsystems, Tarmac Quarry Products, Wessex Water Facilities Management, and Yorkshire Water.

ENVIRONMENT AGENCY

the NATURAL STEP

A Framework for Sustainability

Scientific and Technical Information Service
The Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD

Tel: 01454-624400
Fax: 01454-624409

E-mail: stefan.carlyle@environment-agency.gov.uk
http:\\www.environment-agency.gov.uk

The Natural Step UK
9 Imperial Square
Cheltenham
Gloucestershire GL50 1QB

The Natural Step office in the UK is an activity of Forum for the Future, Charity Number 1040519

Tel: 01242-262744
Fax: 01242-524445

E-mail: info@tnsuk.demon.co.uk
http:\\www.naturalstep.org.uk