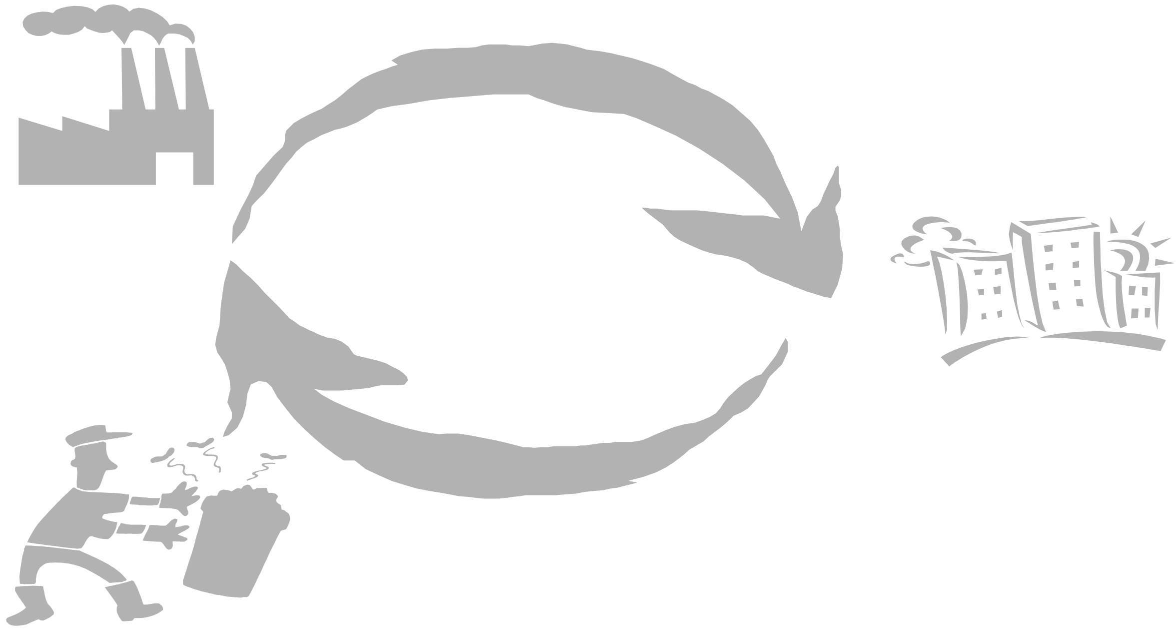

Towards the Sustainable Use of Material Resources

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1. Introduction

There is growing interest in resource efficiency of materials, whether they be of plastic metal or glass, with policy makers, the business sector, investors and regulators concerned to find new ways of 'getting more from less'. Not all of the focus on increasing the efficiency of material use is driven by sustainability concerns. The need to do more with less is often expressed purely as economic, improving our competitiveness in world markets. By contrast, the inclusion of this topic here is motivated purely from a sustainability perspective.

This paper focuses on a project undertaken by the Natural Step in 2002, which as part of the journey towards a sustainable society, considered the way materials are used, rather than the material type. The project was intended to inform decision-making, favouring the reduction of human-induced resource flows to a level and content which stops them over-loading natural systems or denying others the capacity to meet their needs.

The strategic sustainability tool used in the study was The Natural Step Framework. The Study addressed the way materials and products are used, with material type featuring only where it is germane to use patterns and is as relevant to the stainless steel sector as any other.
The key questions explored in the paper are:

- *Is current resource use sustainable?*
- *What are the factors determining current resource use patterns?*
- *What would sustainable resource use look like?*
- *What steps must be taken to enable sustainable resource use?*

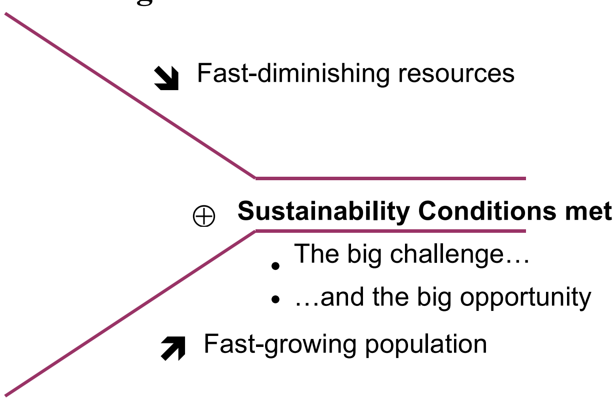
The paper firstly explores the use of the Natural Step Framework for Sustainability before using the Framework in relation to the sustainable use of materials.

2. Application of The Natural Step Framework

We all acknowledge that we live in a fast-changing world, in which the pace of change is accelerating. Thinking back just twenty years, and plotting the changes we've faced – in our day-to-day lives but particularly in business decisions – we become aware of the scale of this change. Although the pressures that have forced these changes may appear random or unforeseeable, many stem from the 'squeeze' of a world with a rising population – which is consuming more and more per capita – and a diminishing resource base. The Natural Step (TNS) uses the metaphor of the 'funnel' to describe how decreasing environmental and social headroom – the 'license-to-operate' granted by a society facing the conflict of rising population and dwindling natural resources – will impinge upon the freedom of operation of a business (Fig 1). As one approaches the 'walls' of this metaphorical funnel, the impacts on business manifest themselves in diverse ways. These include resource scarcity and costs (critically including the resource of absorption of waste), more stringent regulations, reputation with markets and the public, health and safety concerns, difficulty in securing capital, and so forth. Pertinent examples for the material resource use include the impact of increasing environmental taxes, liabilities arising from waste, and implications for corporate reputation. Sustainable development pressures have been with us for many years and will, inevitably and increasingly, define the future business agenda.

The four System Conditions of the TNS Framework provide a science-based conceptualisation of basic conditions that must be met in a sustainable world. From this conceptual model, we can do two things. Firstly, we can make an objective assessment of our current state of sustainability, by running the present resource use life cycle under the 'lens' of the four System Conditions. And then we can build a vision of fully sustainable resource use patterns based upon this same conceptualisation of sustainability.

Fig 1: The TNS 'Funnel'



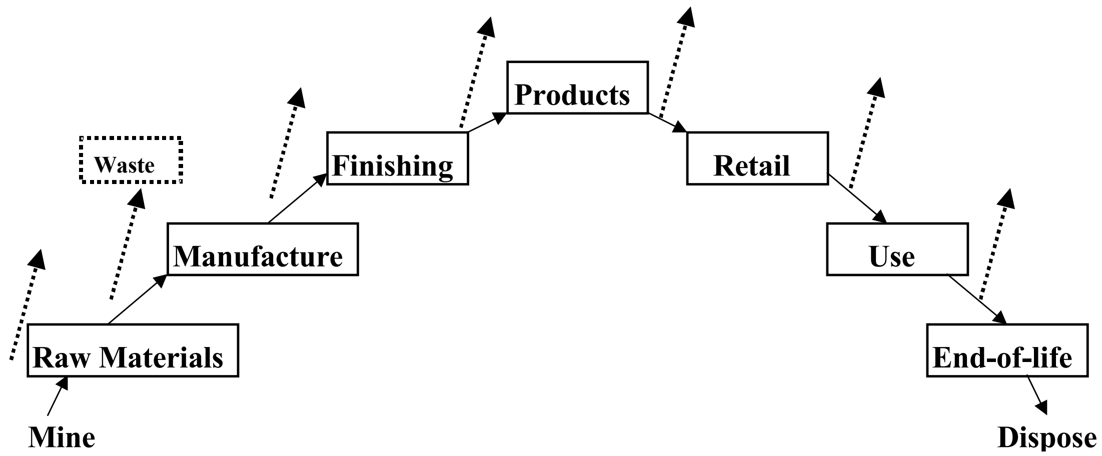
Once we know where we are today and where we need to get to tomorrow, we are then in a position to 'backcast' from this vision, identifying the incremental steps necessary to reach that sustainable future. By starting from the 'end-goal' perspective, backcasting can help make sustainable development tractable. It can also help organisations make short-term investment decisions. These decisions may not deliver the end-goal themselves (full sustainability is remote from where society is today), but nevertheless contribute to a progressive reduction in contributions to breaches of the System Conditions. These short-term measures will then also constitute steps leading incrementally towards further future actions that eventually lead to the desired goal of full sustainability.

If tackled proactively, sustainable development will not only enable us to avoid the 'walls of the funnel' but also to identify the new business opportunities available in a more sustainable future world. Proactive and strategic decisions are more intelligent and cost-effective than merely reacting to sustainability issues that will inevitably arise. A true commitment to sustainable development is therefore about a great deal more than altruism.

3. Sustainability Assessment of Today's Resource Use

Figure 2 illustrates the linear model of resource use – *make, use and dispose* – that has been with us since the Industrial Revolution. Unlike the cyclic resource flows of natural systems, which result in no net accumulation of waste, human-induced linear resource flows *inevitably* lead to an accumulation of waste. Today's resource flows are also very inefficient with losses from the system resulting through processing. Both the continued economic growth in the Western world and the reasonable desire of those in developing countries to attain improved levels of material welfare has resulted in an ever-increasing and unprecedented demand for resources. With this has come accumulation of pollutants, the destruction of ecosystems, wastage, and reinforcement of the inequitable distribution of those resources and impacts: the sustainability pressures contained in the 'funnel' metaphor.

Fig 2: Linear Resource



The four System Conditions of TNS provide an objective and science-based set of principles for making a sustainability assessment of current patterns of resource use. The remainder of this Section summarises some of the sustainability implications of various materials that have been explored in previous TNS studies. These include both adverse and positive sustainability implications although, since we live in a deeply unsustainable world, it should not be surprising that the former outweigh the latter. This Section is concluded by a brief interpretation of this sustainability analysis.

TNS System Condition 1:
In the sustainable society, nature is not subject to systematically increasing concentrations of substances extracted from the Earth's crust

A number of unsustainable practices and factors summarised below contribute to a breach of this System Condition. (These are outlined in further detail in the full project report.)

- **Leaching of mined minerals** contributes to widespread pollution, including eutrophication of soils and water.

- **Overburden and mining waste** is the predominant waste stream in some countries and, in some developing countries, occurs with less stringent environmental and human health regulations. Balancing the negative environmental consequences, mining may be an important form of economic development in many developing nations.

- **Fossil carbon resources** are used in the life cycle of all materials studied, including combustion to produce energy (directly or indirectly) or provide transport. Emissions from fossil fuel use are often excluded from traditional assessments since their use is indirect.

- **Linear flows of minerals** post-use. Often, recovery is uneconomic if metals and minerals enter mixed waste streams.

- **Metal flows** from a wide variety of sources inevitably leads to contamination where they are not recovered.

In addition to the negative implications above, there are also instances of measures and mechanisms that are helpful in moving towards sustainability. These include:

- **Carbon sequestration through afforestation/reforestation** offers the opportunity for industry to offset some of its carbon emissions, also providing habitat.

- **Renewable energy** will be of increasing importance, though energy minimisation and efficiency has a greater capacity for progress towards sustainability in the short term.

- The **market price of copper** creates an incentive for efficient recycling at end-of-life.

TNS System Condition 2:
In the sustainable society, nature is not subject to systematically increasing concentrations of substances produced by society

A number of unsustainable practices and factors summarised below contribute to a breach of this System Condition. (These are outlined in further detail in the full project report.)

- **Loss of materials throughout product life cycle**, for example through volatile compounds 'out-gassing', leaching to water, degradation leading to formation of dust.

- **Uncontrolled emissions from production and disposal of organic materials containing chlorine** are of particular concern due to potential formation of toxic, and often very stable and bioaccumulative organochlorine compounds.

- **Synthetic materials used in building and infrastructure**, particularly in composite materials bonded with glues and cements that reduce their recyclability.

- **Waste PVC, paper and other materials** can, if not reused or recycled, result in the accumulation in natural systems of unnatural and toxic substances.

- Losses of synthetic substances via **consumables** used throughout product life cycles can be substantial in quantity, and are frequently overlooked in environmental assessments.

- **Pesticides** not only have direct toxic effects, but can also accumulate in nature with diverse and often unpredictable consequences.

- **Sludge** derived from sewage treatment or industrial processes may carry contaminants or exceed the absorptive capacity of soils if applied in excessive volumes.

In addition to the negative implications above, there are also instances of measures and mechanisms that are helpful in moving towards sustainability. These include:

- **Sulphur dioxide emissions** have fallen since the 1970s because regulation is tighter and the number of SO_2-emitting processes has declined.

TNS System Condition 3:
In the sustainable society, nature is not subject to systematically increasing degradation by physical means

A number of unsustainable practices and factors summarised below contribute to a breach of this System Condition. (These are outlined in further detail in the full project report.)

- **Mining and quarrying** destroys or degrades habitats by physical means, and should therefore be managed at the minimum level that is consistent with meeting human needs.

- **Physical impacts of fossil hydrocarbon use** (extraction, shipping, refining, spills, diffuse releases, etc) inevitably damages or destroys habitats.

- **Forest product use** still commonly contributes to destruction of old-growth forests and habitat-rich secondary forests, resulting in a potentially catastrophic loss of biodiversity.

- **Land take** for manufacturing and processing plants, office accommodation, transport and other infrastructure, etc., contribute to incremental loss of habitat and productivity.

- **Water Use** in manufacturing and processing of many materials including metals, or growth or harvesting of others, can be substantial. This is often overlooked in environmental audits.

- **Waste disposal** perpetuates linear use patterns, is itself resource-intensive, and can use up space if waste is sent to landfill (with associated long-term pollution and health risks).

In addition to the negative implications above, there are also instances of measures and mechanisms that are helpful in moving towards sustainability. These include:

- **Forest industries** can help mitigate urban migration and sprawl by providing employment in rural areas, and may contribute to the health of the rural economy.

TNS System Condition 4:
In the sustainable society, human needs are met worldwide

A wide range of social and economic factors contribute to a breach of this System Condition.

- Inequitable access to resources such as food, shelter, energy, money and bargaining power can have a huge impact on **stakeholders**. Inequitable sharing may be directly contributory to social instability.

- **Disproportionate pollution loads**, relative to shares of economic benefits from global supply chains, occur in less developed regions.

- Linear use and disposal results in **squandering of resources** such that they are no longer available to society following product end-of-use.

- The **artificially low price of virgin resources** perpetuates wasteful use practices.

- The **artificially low cost of disposal of waste** results in the throwing away of economic opportunities from recycling and other more cyclical and efficient use of those resources. (Most 'waste' in fact comprises purified and concentrated forms of material resources.)

- The development of products which focus on meeting **basic human needs** *per se* is increasingly rare.

- Some materials permit human needs to be met more **efficiently**, through higher durability, recyclability, and social value per unit resource.

- **Regulatory drivers** today focus predominantly on maximising the eco-efficiency of steps in the linear flow from source to disposal, the net output being 'eco-efficient unsustainability'. There is a need for more innovation in regulation.

Interpreting this Sustainability Assessment

The natural world within which we live is fully sustainable. Developed world society has established linear resource use habits, inevitably creating waste. These habits are considered below through a range of contexts:

- **Economic context**. Raw materials today are artificially cheap due to the exclusion of many environmental and social costs ('externalities') from market price. Internalising these costs into product price would, in principle, favour more sustainable use.

- **Regulatory context**. Traditionally, environmental politics have focused on 'end-of-pipe' approaches, though more recently have shifted somewhat to inputs. Further changes in regulation are required.

- **Social context**. The industrial economy arose to help society meet its material needs, yet today serves excessive consumption. Society urgently needs to refocus its efforts in prioritising the needs of all people before addressing the luxuries of relatively few.

- **Political context**. Although the need for sustainable development is now widely acknowledged, the will to decouple economic growth from resource use is still lacking.

We are today a long way away from sustainable material resource use. There appear to be no short-term solutions to some contributions to breaches of System Conditions, both economically and practically. However, urgent though the journey is, achievement of the end-goal of sustainability will be long-term. Success will also depend upon partnerships across different sectors of society.

4. Vision of Future Sustainable Resource Use

TNS principles enabled the development of a vision of resource use within a fully sustainable future. In a true sustainable society the system conditions would not be breached. However to reach that end goal is a journey of various steps one of which is the development of sustainable resource use patterns includes the convergence of the concepts of wastes and resources, and transition to a cyclic economy (noted in Fig 3 which also indicates challenges in moving from the today's linear system).

Fig 3: Towards the Cyclic Use of Material Resources

This vision is not a more eco-efficient version of today's resource use patterns, which are linear and thereby inherently unsustainable. It is much more radical than that. It reflects the pressing need to adapt the production and use of materials to match the sustainable and cyclic patterns of resource flows in the natural world.

The vision strongly emphasises the behavioural, regulatory, economic, social and value-oriented aspects of resource use. The technical steps were by and large already possible, but it was the lack of will for change within society that created socio-economic obstacles to their application. Key issues raised by this are:

- **Dematerialisation**. The economy would be designed to deliver services in a sustainable manner rather than material products in a throw-away culture.

- New **reporting and accounting systems** will have driven changes in governance and business performance.

- Individuals would have more **awareness, ownership and empowerment** about the limits to the Earth's carrying capacity, and of the impact of their material demands.

- **Greater value in activities that don't consume resources** as a result of the transformation of the economy.

- **Economy at the service of society**, re-framed to satisfy material human needs while respecting human, social and environmental systems.

- **Labour value – materials value**. The true cost of the use of resources would be internalised in product prices. Labour would be more valued.

- People would be more conscious of the difference between Needs and Wants, and **materialism and consumerism** would not drive individuals' priorities and values.

- **Vibrant social fabric**. Moving beyond our materialistic behaviour, we would make the most of our human qualities and live in a caring society with a strong social dimension.

- **Environmental justice**, including a rejection of 'NIMBYism'[1] and the flawed concept that waste disappears once it is 'binned'.

- **Local versus Global**. People would generally agree that, while not everything can be produced locally, not everything should come from far away.

- **A 'zero waste' economy with closed-loop material use**. The dispersion of materials to the environment would be limited so as to avoid exceeding the Earth's carrying capacity.

- The concept of **industrial ecology** would have been recognised as a valuable framework for designing and operating industrial systems as living systems interdependent with the natural system.

- **Design for sustainability** would be a fully integrated process from the earliest stage of the production process, avoiding wastage of resources, environmental impacts and premature disposal.

- Firms would view themselves as participants in a **chain of production** and create a dialogue among suppliers, customers.

- **Product durability** would be envisaged at the design stage through the choice of materials, assembly methods, the potential for repair and upgrade, etc.

- **Substitution** of materials will address resource use efficiency (limiting non-recyclable resources) and sustainable waste management (substances that do not accumulate).

- **Marketing sustainable resource use**. Marketing would have played a major role in embedding sustainable development concepts into everyday life.

- **Extended producer responsibility** (and liability) beyond direct stakeholders will be commonplace.

- The principle of **investor responsibility** would have been developed as a practical example of wider stakeholder responsibilities.

- **Corporate governance** would act to increase the accountability of multinational companies and international organisations such as the WTO and IMF.

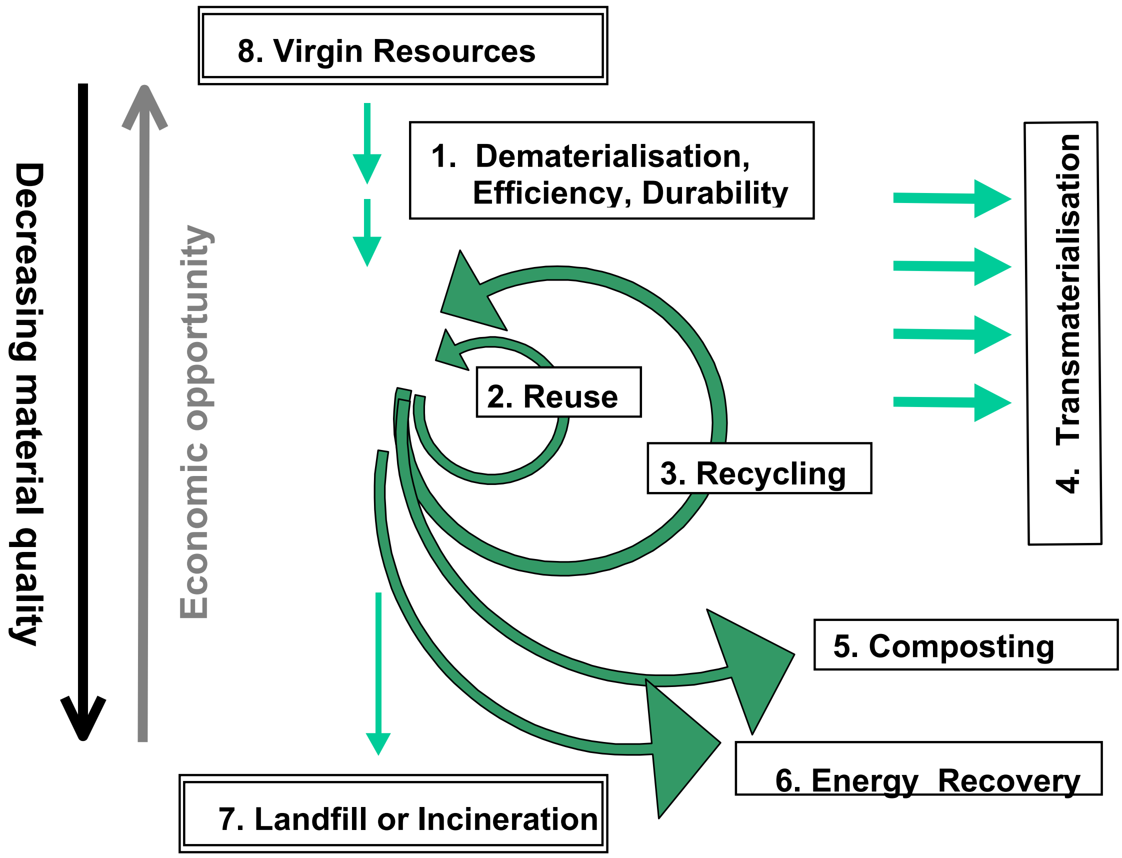
- A shift in **from linear to cyclic systems** will have been achieved.

[1] NIMBY is an acronym standing for Not In My Back Yard.

5. The 'Cyclic Hierarchy'

The concept of a *Cyclic Hierarchy* emerged as helpful in guiding day-to-day decisions about material choice. It also provides keys into the right types and sequence of questions that those specifying materials might explore. The essence of this *Cyclic Hierarchy* is slowing the flow of material resources through society, maximising their value to society in the journey from source to reintegration into natural processes (where material quality is rebuilt). The model is outlined in Fig 4, with the supporting questions in Table 1.

Figure 4: The Cyclic



Linear use represents a sharp drop in quality of materials, both in terms of material and economic value, from virgin to 'waste'. The approach of the *cyclic hierarchy* is to seek to slow the plummet from high to low value, maximising social value and economic opportunity throughout the life of the materials. Table 1 below focuses on these implications from the perspective on the numbered items in Fig 4.

Table 1: Questions to be Asked in Addressing the *Cyclic Hierarchy*	
1. Dematerialisation, efficiency, durability	• Can the demand be satisfied with a *service* approach, rather than through material *products?* • Can the *service* under consideration be met without the use of materials, or in less material-intensive ways? • Can the product or process be designed more efficiently to maximise value/durability per unit material resource?
2. Reuse	• Can the product or process be designed to aid the reuse of: - The whole product? - Components of the product? • What economic opportunities are there available to promote reused products and components?
3. Recycling	• Is the product designed in such a way that recycling of component materials is maximised? • Is physical recycling possible (for example, grinding and melting of plastics)? • Are there chemical (feedstock) recycling routes? (These are generally more energy and chemically-intensive than physical recycling routes, which are therefore favoured.) • What economic opportunities are there available to promote recycling of used products and components? **Note: recycling should always be directed at maximising beneficial use through the preservation of material quality and economic value. <u>Down-cycling</u> is an option only where higher-value options are not possible.**
4. Transmaterialisation	• Where material will inevitably be released into the biosphere by breakdown throughout life or linear disposal, can the material be substituted with another that is more readily reintegrated by natural systems or which will be less harmful?
5. Composting	• Can non-reusable or non-recyclable component materials be degraded biologically to produce compost, which can be used to deliver further social benefits (and divert waste from 'disposal' routes)?
6. Energy Recovery	• This is a low-value (linear) option and may only apply to contaminated waste such as medical applications. • Have all other options been considered to avoid this loss of value? Or is the material used already degraded in quality through many cycles of use by society? • Pyrolysis and other 'cutting edge' technologies should be used to minimise pollutants and maximise energy recovery if disposal is the 'last resort' option.
7. Landfill and Incineration	• This is the lowest-value option and should be avoided. • Have all other options been considered to avoid this loss of value? Or is the material used already degraded in quality through many cycles of use by society? • Have all contents that can not be reintegrated by nature be eliminated from waste upstream?
8. Virgin Resource	• Is the use of virgin resources essential, or can its use (or the requirement for its use) be challenged or averted by other recycled inputs? • Are the virgin resources sourced in ethical and ecologically sustainable methods?

New business opportunities are presented through each question, with the aim of maximising cyclic use. Different solutions may be applicable at different geographical scales and for different materials. <u>All</u> solutions should be applied as far 'upstream' – at source and not in the 'downstream' consequences – as is possible. This is a logical extension to producer responsibility that also represents good stewardship and economic opportunity.

6. Key Sustainability Challenges

The vision identified is very challenging, yet does reflect some of the changes that are inevitable due to the 'funnel' effect. We can address change proactively, as both a necessity and an opportunity, or else react to change at net cost and disruption.

By 'backcasting' from the vision, it is possible to identify steps that can be taken today that not only help us make progress towards sustainability but also do so in ways that facilitate further steps we need to take in future. This process helps make sustainable development tractable, and also helps decision-makers identify the short-term decisions that form incremental steps towards sustainability.

The study identified that technical issues are not perceived as the major barrier to delivering more cyclic use of resources. These are perceived as 'do-able', once the constraints of economic pressures and behaviour have been addressed. The key sustainability challenges therefore broke down into three broad groupings covering cultural, economic and technical dimensions and outlined below.

The Challenges of Cultural Change

Challenge 1: Changing the 'throw-away' culture
Challenge 2: Design for sustainability through cross-sectoral partnerships
Challenge 3: Sustainable regulation and a 'beyond compliance' culture

The Challenges of the Economic Framework

Challenge 4: Creating long-term business thinking
Challenge 5: Internalising environmental and social implications throughout the life cycle
Challenge 6: 'Joined up' economics
Challenge 7: Seizing the new economic opportunity

The Technical Challenges

Challenge 8: 'Intelligent' use of material resources
Challenge 9: Establishing performance-based standards

These challenges apply to the steel sector as much as any other material and need to be addressed in order to move us to a sustainable society.