Environmental Management in the Steel Sector: 
the Need for Integration

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ABSTRACT

Since the 1970s the steel sector, like many other pollution-intensive heavy industrial sectors, has had to respond to increases in environmental regulation and environmental consciousness (amongst consumers and ‘neighbours’). Initially the response was led by technological change, with the application of ‘end-of-pipe’ capture systems. During the 1980s and 1990s there have been developments in the area of environmental management, shifting the focus onto the need to link technology with competent human resource management and training, also in considerations of inputs and process technologies in order to reduce emissions (in preference to capture systems). This presentation argues three points: one is that the drive towards ‘cleaner’ technologies and increased recycling should be sustained and amplified; secondly that the human resource factor in environmental protection and control should be highlighted; and thirdly that there must be an integration of environmental issues with company financial considerations for environmental performance to be improved.

This presentation/working paper is linked to an EC-funded (Fourth Framework on Environment and Climate) project: Environmental Regulations, Globalisation of Production and Technological Change.

The project is a three-year investigation into the environmental strategies of ‘pollution intensive’ industries in the European Union as compared with their counterparts in developing economies, and the implications of these strategies for production, trade and competitiveness. Other members of the research group are based in the Department of Human Geography, University of Oslo, and the Institute of New Technologies, United Nations University, Maastricht.
Introduction

Alongside the chemicals industry, pulp and paper, mineral processing, and other targeted sectors, the iron and steel industry has been categorised as a leading ‘pollution intensive’ activity. This labelling, from the 1970s, is now challenged by business managers who claim that the significant reductions in emissions and energy utilisation achieved since that time now makes the industry merely a ‘potentially polluting’ industry. It is true to say that their claim for the iron and steel industry (the amalgamation of the processes of iron making, steel making and the primary and secondary transformations of steels) has some merit, but herein lies the complexity of the environmental issue in terms of heavy industry.

It is true to say that the pollution reductions achieved in the last twenty-five years in the iron and steel sector have been considerable. However, there is a counter-argument, principally from the non-governmental sector and environmental pressure groups, that these reductions need to be reduced still further and within a relatively short time frame. The authorities, principally government regulatory bodies, have to steer a path between the interests of public consciousness and environmental sustainability and the interests of industry and business. Although significant utilisers of environmental resources, impacting heavily on local and transboundary environments, industries are also large-scale employers in most localities, impacting heavily on local economies. This debate, between environmental sustainability and economic sustainability in local and regional contexts, is an important dimension to the environment-industry issue. The balancing act that regulatory authorities seek to achieve is a difficult one.

There is a large gap between the perceptions of iron and steel industry managers and the environmental and ecological movements and authorities engaged in regulations, pollution control and public awareness. It is this gap, in perceptions and real emissions, that has to be minimised if the iron and steel industry is to be accepted as an ‘environmentally friendly’ or ‘environmentally sustainable’ industry, and not be subjected to public pressures (from the state or civil society) regarding its production activities vis-a-vis the environment. These pressures have been translated into regulations at local, regional, national and international level in order to reduce industrial emissions and promote more sustainable practices in the industry.

This paper argues three points. Firstly, that the developments relating to ‘cleaner’ technologies and recycling should continue to be favoured by government and promoted by industry. In itself this is a recognition of the need to examine the industrial process rather than purely emissions capture and disposal, and it also leads to the statement that environmental technology is also process technology.

The second point is that human factors in environmental management should be highlighted and linked more clearly with technology. Technology in itself cannot lead to environmental performance improvements; the management and maintenance of equipment and improved operational capacity of equipment are increasingly important. This is the human dimension to environmental management that requires greater concentration on environmental training and awareness within the company, and also improved public relations on environmental issues with company ‘neighbours’ (residents and other companies).

The third point relates to the need to link environmental costs with company costs. Currently there is inadequate
environmental accounting to build on the developments in environmental auditing in heavy industrial sectors. Effective environmental accounting requires finance management support and modifications to existing financial management systems. More than anything, this step requires changes in attitudes in company management. Until there are effective systems of environmental accounting it is unlikely that there will be adequate information available on which to investigate whether environmental spending may actually provide companies with benefits to counter the cost impacts.

The Steel Sector: Production and Contamination

Sectoral Responses to Pollution

It is not without justification that the iron and steel sector was brandished as ‘pollution intensive’ or ‘dirty’ prior to the 1970s; the sector has struggled to shed this negative image. Due to volumes of raw material needs, energy needs, production volumes, and associated input-output components, the industry is indeed a significant emitter of a range of by-products, despite a dramatic curtailing of these emissions. In terms of preoccupation for environment managers in the iron and steel sector, air emissions precede water discharges, followed by solid waste, noise and soil remediation issues.

The characterisation of the iron and steel industry as a leading ‘dirty’ industry’ is highly interconnected with the plumes of smoke that emerge from its facilities. The image is a negative one, despite the fact that this smoke is predominantly steam vapour from cooling processes within the system. There is an issue of perception here. Nevertheless, atmospheric emissions are a significant cause of concern for producers, in order to meet regulatory standards across a wide range of pollutants, from SO₂, CO₂ and NOx to zinc, molybdenum and cadmium. The principal strategy utilised against atmospheric emissions continues to be end-of-pipe collection. Whilst attention to the quality of raw materials and better use of those materials, thus ensuring more efficient transformation and reduced by-product emissions, is gathering ground, air emissions account for the largest investment in environmental technologies.

Water pollution control is generally well advanced in the industry and now constitutes only minor problems. Despite significant advances in this area, regulatory authorities often choose to penalise plants on their water discharge infringements rather than on air emissions. The reason for this is a simple one of monitoring. Air emissions are difficult to monitor from the stacks, although surrounding immisions and boundary emissions can be monitored more easily. Nevertheless, both regulators and producers struggle to continuously monitor air emissions. Water emissions, on the other hand, can be sampled easily from discharge points. Although firms are concerned that they meet water emission standards, most of the water issues relating to iron and steel production have been resolved. The principal means has been the recycling of water within closed or semi-closed circuits within the whole plant, cascading from one piece of equipment to the next, or independent systems for each major operation in the production process; water preservation with the use of circuits can be in the region of 95%.

On-site treatment plants also ensure that water discharges meet the standards required. Each plant has its own particular water issues, ranging from brackish water availability which impacts upon equipment efficiency, to the case of a Belgian producer which changed its use of acids for the pickling process in order to reduce nitric acid concentrations which were resulting in high nitrogen emissions in the low flow water discharge stream. This is an example of where regulations have led to innovative responses within the production process rather than an end-of-pipe response.
Noise pollution varies considerably according to site. In many areas, production facilities grew up in towns and cities during the nineteenth century and the separation of site and residential areas is limited. A more contemporary issue is the encroachment of residential areas on the limits of industrial spaces. In this way, local planning authorities have provoked conflicts. Environmental corridors, planted with trees to reduce noise, or open spaces have not been employed. The result is that firms have had to initiate a range of strategies. Noise abatement strategies range from wall construction to dampers on production technologies, particular fans for ventilation (often environmental technologies themselves), and the enclosing of equipment.

Other wastes/by-products and pollution media include solid wastes such as blast furnace and steelmaking slags, sludges, and the issues of demolition of redundant plant and subsequent soil remediation. The use of slags in construction and cement production is important for producers, providing an outlet for these by-products, although in many regions and countries there are politically-motivated decisions regarding slag use. In areas where aggregate mining is an influential sector, there is an argument for the use of mined products. Another political issue is the extent to which construction programmes are being carried out and how new road construction relates to plant location, thus slag transport costs.

The restructur ing of the older regions of iron and steel production has led to major transformations. The outcome has been the closure of excess capacity. Not only has this had tremendous social impacts, but also there is an on-going problem of demolition and soil remediation. Each of these issues poses a range of problems that are linked to environmental protection by steel producers, and for which they pay the costs, i.e. demolition entails its own significant dust problems, and soil remediation can be problematic and costly.

With all these pollution media, a significant problem for the steel sector has been information regarding the extent of emissions and the ability to compare firms and experiences. The principal conclusions of the 1996 European Commission report on steel and environment based on questionnaire responses from European firms were as follows:

* data collection on parameters involved in the environmental impact of the steel industry is largely incomplete
* future cooperative effort by the European steel industry towards better environmental control needs an important effort to be made in standardising measurement methodology
* development of suitable sensors is necessary

* one of the objectives of the study was to evaluate the total investment required in order to improve the whole of the European steel industry to a point at which it could respect the best available industrial techniques. This objective was not achieved, and apparently cannot be reached through a global approach as made in this study

Until there is standardisation of monitoring and accounting, it will be difficult to move beyond superficial understandings of steel sector environmental impacts and performance assessments. This situation is neither good for company strategy and prioritisation of resources, nor for the dissemination of information relating to the environment.

The Internationalisation of the Industry-Environment Debate

Whilst there has been increased attention on environmental issues within industry since the 1970s, international environmental conferences from Stockholm to Rio, also declarations regarding environmental sustainability such as in Meadows et al.’s Limits to Growth and the Brundtland report, have intensified environmental affairs on the industrial and commercial agenda. The main reason for this is the transboundary nature of environmental change, a further reason is the context of globalisation within which environmental change takes place. For these reasons, it has been impossible for companies (excepting some small and medium-sized enterprises catering exclusively to the domestic market) to avoid
international pressures for improved environmental performance. Increasingly international environmental pressure is moving towards the so-called ‘level playing field’ whereby firms should be subject to equally stringent environmental standards and regulations wherever they operate in the world. This is a response to the ‘pollution haven’ hypothesis.

The ‘pollution haven’ hypothesis is an assumption built in to debates relating to environmental regulations and their impacts on firms. The assumption is that there is a global playing field and movements of firms, investments and products will take place across this field as regulations create gradients due to their strengths and weaknesses in different countries. The commonly-held belief is that as regulations become more stringent there will be a movement to sites of more relaxed controls. Whilst this assumption might appear to be a logical one, based on firms making optimal and rational decisions, there is little evidence to support it. This is because firms are not necessarily economically rational due to the complex interplay of numerous interconnected factors relating to production and trade, and also because the simplicity of the notion of movement across the global playing field is not a realistic one.

Multinational firms have become highly aware of environmental and most have implemented globalised standards. This suggests that the ‘Bhopal Cases’ have been lessons learned; firms like Union Carbide now institute the same equipment and procedures in North Carolina and in India. This argument goes one step further. Because many multinationals have recently expanded production to developing countries, for reasons of domestic markets rather than low regulation, they have invested in state-of-the-art plants and equipment that exceed the standards of those in place in their developed world locations. This argument has been termed ‘leap-frogging’.

Despite the evidence weighing against the existence of pollution havens, there are certainly cases where environmental experiences of firms are affecting competitiveness. In this way, environmental factors are increasingly becoming economic factors for firms. If one takes, for example, the European Union’s Competitiveness Database definition of competitiveness, one can identify that within the global market place that there are many examples of the links between environmental management and firm performance (“...the ability of a firm, on a sustainable basis, to satisfy the needs of its customers more effectively than its competitors, by supplying goods and services more efficiently, in terms of price and non-price factors, than these competitors”).

With industry-wide pollution abatement costs running at below 5% of total production costs, the suggestion that environmental regulations are shaping international trade patterns (purely because environmental issues have been pushed onto the business agenda recently) is misleading. Rather than overarching generalisations regarding environmental regulations and production and trade, there is a need for case study analysis to assess the extent to which firms are responding to regulations (environmental management), the extent to which firms are proactive or reactive, and the extent to which they see regulations still as costs rather than benefits within their corporate strategies.

If the environment is to be considered significant within competitiveness indicators, pollution abatement costs must be higher than at present. Where the environment becomes important is in innovation. If one follows the Porter argument that regulations lead to innovation, one can credit the developments of end-of-pipe technologies, and the more recent
transition to process and production methods of contamination reduction, to regulations. In this way, regulations have played an important part not only in controlling emissions and waste but in promoting the development of efficient industrial technologies.

As environmental debates have become increasingly internationalised, so too has the iron and steel industry. Since the 1970s, the sector has become increasingly globalised. In 1994, there were 1175 steel plants registered (990 Electric Arc Furnaces, 221 Blast Oxygen Furnaces). As total production has slowed, developing economies have increased their share to match their increased domestic demand.

Table 1: Average Growth Rates (% pa), World Crude Steel Production

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<tr>
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</thead>
<tbody>
<tr>
<td>1950-60</td>
<td>6.2</td>
<td></td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>1960-70</td>
<td>5.5</td>
<td></td>
<td></td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>1970-80</td>
<td>1.9</td>
<td></td>
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</tbody>
</table>

Source: IISI (1996)

Table 2: Steelmaking Costs by Country ($US per tonne)

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>413</td>
</tr>
<tr>
<td>USA</td>
<td>513</td>
</tr>
<tr>
<td>France</td>
<td>493</td>
</tr>
<tr>
<td>Germany</td>
<td>558</td>
</tr>
<tr>
<td>Republic Of</td>
<td>511</td>
</tr>
<tr>
<td>Japan</td>
<td>572</td>
</tr>
<tr>
<td>Taiwan</td>
<td>511</td>
</tr>
</tbody>
</table>

Source: Marcus and Barnett (1993)

Table 3: Regional Steel Production Capacity (based on 80% utilisation rate, Mt)

<table>
<thead>
<tr>
<th>Region</th>
<th>1996</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Europe</td>
<td>172.0</td>
<td>175.0</td>
</tr>
<tr>
<td>Central and Eastern Europe</td>
<td>115.0</td>
<td>120.0</td>
</tr>
<tr>
<td>North America</td>
<td>125.0</td>
<td>140.0</td>
</tr>
<tr>
<td>South America</td>
<td>36.0</td>
<td>40.0</td>
</tr>
<tr>
<td>PR China</td>
<td>100.0</td>
<td>110.0</td>
</tr>
<tr>
<td>Japan</td>
<td>102.0</td>
<td>105.0</td>
</tr>
<tr>
<td>Other Asia</td>
<td>95.0</td>
<td>130.0</td>
</tr>
<tr>
<td>Total</td>
<td>777.0</td>
<td>860.0</td>
</tr>
</tbody>
</table>

Source: Steel Times (February 1997)

Table 4: Steel Production and Consumption, 1985 and 1995 (%)

<table>
<thead>
<tr>
<th>Region</th>
<th>Production 1985</th>
<th>Production 1995</th>
<th>Consumption 1985</th>
<th>Consumption 1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Europe</td>
<td>22.1</td>
<td>22.7</td>
<td>18.3</td>
<td>21.4</td>
</tr>
<tr>
<td>North America</td>
<td>13.2</td>
<td>14.4</td>
<td>16.8</td>
<td>17.3</td>
</tr>
<tr>
<td>Japan</td>
<td>14.6</td>
<td>13.6</td>
<td>12.0</td>
<td>12.2</td>
</tr>
<tr>
<td>PR China</td>
<td>6.5</td>
<td>12.4</td>
<td>9.4</td>
<td>13.6</td>
</tr>
<tr>
<td>Other Asia</td>
<td>5.7</td>
<td>11.3</td>
<td>7.5</td>
<td>18.2</td>
</tr>
</tbody>
</table>
(former) USSR 21.5 10.5 20.5 5.7
Eastern Europe 8.3 4.6 5.7 2.6
Latin America 4.0 4.4 3.9 3.9
Others 4.1 6.1 5.9 5.0

Source: IISI (1996)

Table 5: Major Steel Producing Countries, 1995 (million metric tons crude steel production)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Capacity</th>
<th>2nd Country</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Japan</td>
<td>101.7</td>
<td>Rep. of Korea</td>
<td>36.8</td>
</tr>
<tr>
<td>2</td>
<td>US</td>
<td>93.5</td>
<td>Italy</td>
<td>27.8</td>
</tr>
<tr>
<td>3</td>
<td>PR China</td>
<td>93.0</td>
<td>Brazil</td>
<td>25.1</td>
</tr>
<tr>
<td>4</td>
<td>Russia</td>
<td>51.3</td>
<td>Ukraine</td>
<td>22.3</td>
</tr>
<tr>
<td>5</td>
<td>Germany</td>
<td>42.1</td>
<td>India</td>
<td>20.1</td>
</tr>
</tbody>
</table>

Source: Steel Times (February 1997)

The trend in construction and operation of steel plants since the early 1980s has been very clear. Marginal prices and reduced worldwide production have led to increased competition and cost-cutting (Tables 1-2): in Western Europe capacity has been closed; in developing economies, capacity has been expanded (Tables 3-5). In terms of location of production and consumption, the patterns of steel development have become rapidly globalised and the trading of steel products has become more important, especially for European and US firms. The outcome of globalisation and increased competitiveness within the sector has been criticism of protective mechanisms, labour and environmental exploitation in developing economies which assist companies in being price competitive.

“...The European industry...face growing international competition from both the highly advanced American and Japanese industries and new players from Eastern Europe and the developing world, which often exploit cheap labour and materials with scant regard for the environment. A competitive European industry is therefore as crucial as ever. The only viable response is advanced technology, requiring constant research, development and innovation.” (European Coal and Steel Community 1994, p.1)

The arguments regarding environmental exploitation are often unsubstantiated by research, especially when it relates to more competitive producers (as opposed to Chinese production for example). On closer observation, it is apparent that environmental management within the industry is more complex than that characterised by simple North-South divisions for example. Rather than criticisms of companies, there should be a movement towards improved standardisation and the promotion of better environmental management throughout the sector. The following three sections discuss considerations that should be included.

**Business Strategies: Towards Cleaner Production**

Technological developments with environmental performance objectives in the iron and steel industry fall principally into the category of end-of-pipe technologies. These technologies, alongside environmental management procedures and strategies, provide the backbone of environmental responses within the industry. The end-of-pipe technologies employed in plants are relatively similar throughout the world; dust collection, filtration, and treatment technologies trap and separate a range of by-products. The iron and steel industry has made significant steps in reducing off-site deposits of its
by-products. If by-products cannot be put back into the furnaces, or useful metals separated from dusts, these have to be landfilled at increasing cost. These costs have led to innovative approaches for recycling of by-products. Currently firms aim to reuse, sell or recycle over 90% of their products and by-products. In a typical integrated steel plant (figures for Sidmar N.V., Belgium):

67.3% of production is steel, with the following by-products:

- 21.0% Blast furnace slag, sold and used in the cement industry
- 6.7% Steel slag, sold and used in the road construction industry
- 2.3% Inert building rubble, recycled
- 1.2% Benzol, sold
- 1.2% Other slag, sold
- 0.3% Waste products, authorised deposition in landfill

With treatment and deposition costs rising and uncertainties regarding future regulations, firms are reducing waste to a minimum. A problem that the steel industry faces in some countries is the classification of certain by-products as wastes (such as certain slags) despite the fact that they are sold as inputs into other industries. The European Confederation of Iron and Steel Industries is pursuing these classification changes and the removal of selected by-products from ‘Green Lists’ of waste products.

In terms of industrial evolution, the future of more flexible and environmentally-friendly iron and steel production will come via mini mills with near net shape casting production, also through increased computer-aided production. Nevertheless, with half of all steel production still expected to be ore-based (albeit produced in more efficient blast furnaces), the ‘dirtier’ elements of the steel production process will remain to some extent; this ore-based steel is required for particular types of products such as strip steel. With the continuity of such elements of production, it is likely that end-of-pipe technologies will continue to play an important role in the industry. Apart from these developments, the areas of significant change are in the attempt to reduce emissions from sinter plants, the generalised use of secondary dust abatement, continued developments in water economy, and the shift from the Blast Oxygen Furnace route to the Electric Arc Furnace route of production within limits of scrap availability. Within the EAF route itself, developments include improved water circuits, better treatment of solid wastes, and continued improvements in secondary emissions collection and dedusting.

A major change in technology within the industry came about in the 1970s. In the same way as Open Hearth production systems (a slow and inefficient process of heating raw materials in saucer shaped vessels) gave way to the Basic Oxygen Process during the mid-twentieth century, the development of the Electric Arc Furnace during the 1970s has revolutionised the industry. During the 1970s, the contribution of electric arc production to total production rose from 15% to 25%.

The BOF process replaced fire with oxygen for heating raw materials, resulting in quicker and more efficient production. The EAF process relies on electricity as its source of heat and differs from the BOF in that it uses scrap steels as the principal raw material. These two systems (BOF and EAF) have developed alongside one another since the 1970s and the balance between them will continue since the BOF system is still required to produce virgin steel, without which there would be insufficient quality scrap for new EAF steel production. The two systems complement each other and it is difficult to discuss their environmental impacts one against another. It is not simply the case of identifying the cleaner production system of the two and discarding the other, since they are not mutually exclusive. Instead, each system has its own technical and environmental complexities which have to be tackled, i.e. for the BOF, there is the issue
of air emissions from coke and sinter plants, whilst for EAF producers there is the dust and heavy metals issue to be addressed.

In each different process, there are constant incremental developments in technology, which in most cases have positive impacts on energy and environment. In fact, several technical and environmental managers made the point that new production technologies have to reveal positive environmental and energy impacts in order to be accepted and implemented. For example, in the case of the EAF, a shaft furnace system has been introduced in a few plants; this system enables scrap to be heated in a special shaft incorporated into the furnace roof. This preheating reduces energy requirements, leads to a 30% reduction in EAF fumes reaching the baghouse and a higher zinc concentration in the zinc collected. These reductions and zinc concentrations allow for more economic recovery and treatment and have positive environmental impacts. Another development in zinc and lead reduction from dusts has been the fluidised bed reaction piloted in Germany. This system produces selective reductions of these metals from iron oxide by using a CO/CO₂ mixture; 80% zinc and lead removal from dusts can be achieved.

**Iron Production Technologies**

The ironmaking part of the steel process is highlighted by managers as needing attention for its environmental impacts. Before iron enters the steelmaking area of the integrated plant, there are stages of conversion that require combustion within furnaces. The two stages of importance are the coke making process performed in coke ovens, and the sinter process which converts coke into a suitable form to be most effective once it enters the blast furnace with the iron ore. Due to the environmental impacts to air from these stages of the process, much research and development work on the environment has taken place. These processes have traditionally been suppressed by end-of-pipe arrestment systems.

The electrostatic precipitator is the most common system and is efficient in removing 99.9% of dust from flue gases by electrically charging dust particles in the gases which then migrate towards steel electrodes to be collected; dust and metals can then be collected for recycling or disposal. The problem that now faces managers is the separation of finer particles and trace organics (PCBs and dioxins) and radioactive isotopes since these are expected to be targeted by regulatory authorities in the medium-term as other emissions levels are attained. Responding to the largest prosecution case to date taken up by the UK’s Environment Agency, against Coalite Products Ltd. In 1995-96 over its dioxins emissions, British Steel has invested a large percentage of its environmental R&D on the setting up of a Trace Organics laboratory to focus on how dioxins are created, the extent of their dispersal and their cumulative effects.

Although end-of-pipe systems are now almost universally applied, there have been developments in trying to provide ways of by-passing the coke and sinter stages in the iron process. The successful achievement of this would have immense positive environmental performance impacts, however the various developments currently available are not yet applicable across the board for a wide range of reasons: raw material specifics; energy specifics; unproven on a large scale; too expensive, etc. The principal developments are the COREX and the MIDREX systems. A further example is the DIOS (Direct Iron Ore Smelting Reduction Process) system - a coal-fired smelting reduction process - which is concentrated in Japan. The COREX system is the only system to have reached industrial maturity with two plants operating in the world, and it works similarly to the traditional BF route since the raw materials are smelted. This
contrasts with the MIDREX system of direct reduction (hence DRI - direct reduced iron) which does not use an oxygen process, but instead yields solid sponge iron from iron ore using reformed natural gas or coal as the reducing agent; sponge iron can then be melted in the EAF).

Whilst these ironmaking processes are being developed slowly in order to shorten the ironmaking process, there are incentives to accelerate their development and take-up. The advantages of these systems are lower investment costs and improved environmental performance, but in many cases the effectiveness of a particular system will depend on local conditions and raw materials availability. i.e. in South Africa where steam coal is widely available and scrap is scarce, the COREX process is highly effective.

**Continuous Casting**

Continuous casting is a development of the late 1970s and 1980s which has, like the EAF, revolutionised the production of steel. By continuously casting, a stage of the production process has been eliminated. Instead of molten steel being poured into ingot molds and then these being rolled at a later date in the steel mills, the molten metal is cast on a continuous basis by pouring the molten steel into the top of open-bottomed water-cooled molds; the cross section of the mold corresponds to the desired semi-finished shape. This improves yield (less molten metal for the finished product) and quality, also leading to energy and labour savings, and reduced environmental impacts since sub-stages of pouring, cooling, reheating and rolling can be omitted from the production process, thus reducing a wide range of emissions. Currently over two-thirds of global steel production is continuously cast into semi-finished products such as slabs, blooms or billets.

**Motor and Burner Developments**

Within the production system, alterations and changes in motors, burners and other pieces of operating equipment can have significant impacts on energy reductions thus environmental impacts. Controlling temperatures and timings of heat use and motor use have revealed useful savings. In the case of oxygen-fuel burners, the modification of flame temperature has revealed 40-60% reductions in CO₂ and NOx emissions and improved operational performance; these burners are used in several areas of the process such as reheat furnaces, soaking pits and ladle pre-heaters. Since there are many motors in use throughout the production system, minor alterations or simply turning motors off when not in use can have large cumulative effects on energy. Energy savings on motors not only lead to upstream effects on energy needs and energy production, but also to efficiencies in cooling water use, oil use, and other associated elements which are small elements of the plant’s environmental equation but which have cumulative impacts. These minor energy savings are most important in the case of smaller plants, however energy costs and competition will inevitably lead to this attention to detail in the larger integrated plants.

**Recycling**

Alongside its competitor products, aluminium and plastics, the recyclability of steel and its by-products gives it an advantage as LCA, recyclability and sustainability strategies gather pace. The steel industry recycles 425 million tons of
steel each year and the European iron and steel industry has a self-appointed target of recycling 60% of household steel waste by 2005. In 1998 a long-term study on the steel life cycle will be published. Rather than a ‘cradle to grave’ approach, it has focused on a ‘cradle to factory gate’ extent. This was for reasons of complexity of the iron and steel process itself and the sheer variety of products. A number of firms participated throughout the world and particular products were selected. Rather than a Life Cycle Analysis, the intention was to produce a Life Cycle Inventory. The establishment of an Inventory is the first step to working towards a full LCA which would then include assessments of environmental impacts. Since the scale of the Inventory was extensive in itself, the cycle was curtailed (to the product leaving the factory) and the impacts left for further investigation.

The International Iron and Steel Institute made clear its intentions when commissioning the study (carried out by a French environmental consultancy) that the aim of the exercise was not to have an LCI in order to compete with its competitor products, but rather for the industry to establish a clearer idea of the environmental issues downstream and upstream. This awareness will have an important impact on future developments throughout Europe due to the introduction of Integrated Pollution Prevention and Control and the needs of Eco-Management and Accounting Schemes. It will enable steel producers to make environmental strategy links with their suppliers and their customers, and also to respond to the growing public awareness of making environmental connections in their consumption choices; the rise in eco-labelling is one example that is likely to filter down to the white goods and automobile industries in the medium-term which will therefore impact on steel producers.

The synergy between environment issues and energy issues is not lost on iron and steel firms. In many cases, environment managers are also energy managers or have close relations with energy managers, perhaps working within the same department. With energy costs accounting for up to 20% of production costs, the desire to improve energy efficiency has been a significant driver in environmental performance improvements also. When viewed in terms of LCA, these energy concerns and responses are also very influential in terms of energy production and environmental contamination. There is no doubt that energy savings have a positive effect on the overall environmental impact of the firm. With firms aiming to reduce costs by reducing energy demands, environmental improvements will follow. One only has to assess the decline in CO₂ emissions from plants since the 1970s and equate this decline with energy price rises during this period (especially in the 1970s) to note the close association of energy and environment issues.

A concern in terms of energy is that major energy reductions were achieved during the 1970s and 1980s and that the rate of energy consumption reduction has moderated significantly: improvement in energy consumption in Europe during the period 1980-88 was 80%, of which the years 1988-94 accounted for only 20%. Taking a wider view of energy demands in the industry, there are pressing issues that concern business managers, and environment and energy managers in particular. One is the negative consequences for industry of a carbon tax. A positive response has been the need to develop products with steel customers, such as the ultra-lightweight body car.

Despite criticism, the steel industry argues positively on environmental themes. By focusing on the high recyclability of steel, and producing graphs of energy demand, CO₂, NOx and SOx reductions, the industry puts forward the case that it is has been responsive to environmental demands and is innovative in working towards the future. The IISI’s environmental promotion booklet (1993, p.3) *Preparing the Future: towards a better environment* sets out this
argument:

“With their astonishing abilities to respond to new demands, today’s steels are vital to environmental systems which protect air, soil and water. Steel saves resources and reduces waste through its unparalleled capacity to be recycled again and again. Innovations in steelmaking itself bring big cuts in energy consumption and emission levels.”

Environmental Management: The Human Factor

Management practices are the keys to changing attitudes to the environment, as they are in all other areas of industrial activity. Iron and steel companies have been responding to environmental issues since the early 1970s. The leading issue from the 1970s was the reduction of CO₂ and SOx emissions, which were outcomes of the drive towards energy efficiencies following the oil crises. Since the mid-1980s, environmental regulations have driven business. Costs of infringements, with the ultimate sanction of plant closure, the increasing costs of environmental responses due to marginal steel prices and impending customer demands for environmental accreditation have been behind these responses. It is apparent from company publicity and environmental statements, where they exist, that environmental issues are firmly on the corporate agenda. On the whole, the statements of intention are encouraging, although the extent to which this is the case throughout the sector and to what degree this policies are carried through are more debatable.

Corporate Statements regarding the Environment

Sidmar n.v. - ‘Ecocare at Sidmar’

“The general management of Sidmar considers that protection of the environment, both in the near and the distant future, as a priority. This calls upon every employee to put responsible care into practice within his or her own working environment.”

British Steel - ‘British Steel and the Environment’

“At all levels of the organisation, British Steel has a responsible attitude towards the environment. The Company’s environmental management structure has been strengthened at an operational level and environmental audit resources have been reinforced. The Company’s training programme ensures that all employees are aware of corporate environmental policy and that individuals are invested with responsibility for implementing that policy.”

Usinor-Sacilor - ‘Initiatives for the Environment’

“Respect for the environment is a responsibility we all share. Ultimately, our company is committed to its development and prosperity, to the satisfaction of its customers and shareholders, and to the needs of its personnel, while at the same time protecting the environment and natural resources.”

With most companies investing approximately 10% of total investment each year in environmental projects, increased awareness of the environment within total factor production has been achieved. Most companies do not hold with Porter and van der Linde’s ‘win-win’ approach to environmental investments. Compliance is the driver in almost all cases. ‘First mover’ tactics in environmental technologies and management are not clearly apparent. A separation can however be made between large groups of companies - such as Usinor-Sacilor (France), British Steel (UK) and POSCO (Rep. of Korea) - which are advanced in environmental management strategies and environment research and development, and smaller lone companies which struggle to resource environmental needs, from personnel to investments. It is clear from
the larger companies that the forthcoming demands for Life Cycle Analysis, ISO 14000 accreditation and effective Eco-
Management and Accounting Schemes are being tackled vigorously in preparation for future developments in the market
and from regulators.

This environmental pressure from the market place, moving upstream from consumers of steel-based final products
through manufacturers to the steel producers themselves, has been an important development from the late 1980s. It is
no longer solely the regulator bringing pressure to bear on firms, but also steel customers and public pressure at large
regarding environmental issues. In this last regard, many companies have improved their communication with the local
community and local government in recent years. Community relations on environment issues are now linked within
environmental management systems to the essential objectives of meeting regulations.

The positive elements of regulation and environmental management, the benefits, have been recognised only slowly and
it is only recently that they have been. Naturally, regulations lead (or at least should lead) to positive environmental
outcomes, but the connection that business could also gain from these regulations and treat them as a long-term benefit
rather than as a long-term cost is a more recent development. It is Porter and van der Linde who have put forward this
positive, so called ‘win-win’, argument most convincingly. They argue that regulations lead to innovation and
adaptation in order to deal with the cost implications of the regulations. Managers become aware of the need to
recognise efficiencies in production and sales and they introduce more dynamic managerial practices and new
technologies. Whilst this may be costly in the initial stages, the argument is that these firms are well placed in the global
market place as regulations become stricter elsewhere and firms are forced to follow suit. In this way, firms may become
‘first movers’ and enjoy the comparative advantages of having implemented environmental procedures and technologies
at an early stage. An example of this is the German ‘pollution intensive’ industrial sectors where strict early regulations
relating to emissions levels gave rise to a flourishing environmental goods and services industry.

The counter-argument to Porter and van der Linde is offered by Palmer, Oates and Portney who suggest that innovation
is not necessarily an outcome of tighter regulations since some firms may be unable to compete within the new
framework. It is not logical therefore to state that innovation will be a response throughout the industrial sector under
regulation. It is likely that some firms will innovate in response to regulation and others will lose competitiveness.
Unlike Porter and van der Linde, the counter-argument assumes more of a zero-sum game within which not all firms can
gain but firms will gain at others’ expense.

Integration: Environment and Economy

The development of an international environmental agenda from the Stockholm Conference in 1972 led to the
emergence of controls and restrictions on levels of environmental contamination. For the first time, international business had to confront the fact that the environment would have to be regarded as an economic factor, alongside labour, transport and others in considerations of production, trade and consumption. In this way, the environment became valued and recognised as a ‘good’, in terms of sustainability and future natural resource use, and in terms of ‘good economics’ in that there was a recognition that the value of the environment would increase over time with resource depletion and public consciousness and pressure.

The integration of the environment into corporate strategy has been a slow one since the regulations that were constructed at national and supranational levels were initially perceived as costs rather than benefits; the ‘good economics’ concept was slow to filter through to business. This perception was partly due to the fact that early regulations were motivated by ecological pressure groups and political responses. Business was slow to immerse itself in the construction of its own regulatory frameworks and see them as being potentially useful tools for future competitiveness.

At a UNECE seminar on ‘Metallurgy and Ecology’ (Nancy, 10-14 1993), the theme of environmental impact and economic performance was addressed. Three important aspects were raised: uniformity of standards alongside the need for flexibility based on scientific values, clarity, adaptability, and effective application; that of the ‘polluter pays’ principle and the need to identify who is the polluter: the steelmaker, the user of the scrap, of the consumer?; also the legal definitions of waste and the balance between recycling and dumping. These are the same issues that regulators have to engage with since it is not only the issue of emissions control that they have to confront, but also the economic performance of the firm relative to other producers, and its ability to develop environmental strategies.

Regulatory bodies around the world are at varying levels of institutional development and change. In the UK for example, the precursors to the European IPPC Directive are already in place. The IPC strategy is currently in operation and the voluntary BS7750 Environmental Management Standard was introduced in 1992 to prepare for the EC’s EMAS scheme. The variations are important since different bodies have different institutional strategies, leading to varying levels of compliance, although it must be said that most firms seem to meet the targets on most emissions. The greater differences between member states derives from regional and local variations on requirements above and beyond minimum levels. The factors that stimulate firms are highly variable, therefore it is difficult to state that one approach or another should be universally applied. Different firms have different environmental weaknesses, according to process, raw materials quality, geographical location, and other variables.

An important development within the inspection system is the recognition that emissions levels are not solely technical issues. The UK Environment Agency has been developing an approach to inspection that also encompasses the associated factors that link in to business management. The 3E’s approach, is a systematic review process that tries to assist companies by placing environmental performance in the context of the production process; 3E’s addresses: Emissions (primary emissions, secondary emissions, tertiary emissions); Efficiency (relating to process effectiveness, relating to material usage and other efficiencies); Economics (all costs, direct/indirect, short/long term, effects on value
of product). The type of approach is better linked to the business approach to environment issues, since technological development and emissions attainments are inseparable from the other factors of production and investment decisions.

A problem for many companies in terms of the environment is the paucity of data they have regarding the actual costs of environmental strategies. Environmental accounting is not employed outside the Netherlands and the US for iron and steel companies. The separation of environmentally beneficial activities from efficiency and production activities and technologies is extremely complex. By labelling environmental technologies and activities as those which first and foremost improve environmental performance, it is possible to remove certain elements from the complexity but there are significant environmental impacts from other technologies and activities. The development of EMAS in some larger groups will require that they confront this issue, but the comparative nature of this data from firm to firm and country to country may be questionable. In terms of pollution abatement costs as a percentage of operating costs (as available in US Industrial Census data), there is no clear approximation.

Despite the lack of strong accounting for environmental costs, environment managers maintain that costs are significant and increasing. The underlying factor of their importance is that environmental investments and operating costs for the maintenance of environmental technologies and systems (which are themselves significant energy users) are a capital diversion. Instead of these investments being directed into production and the product itself, the environmental costs are not directly product-related. This capital diversion issue is important to the firms; many managers make the claim that if you use capital for the environment, you have to take it from production therefore it is unproductive. For environment managers, the benefits of environmental investments are outweighed by the costs. Whilst these managers understand the logic of the long-term advantages of environmental investments and the adoption of environmental management strategies and initiatives, there are short-term imperatives in the industry which are of significantly greater concern, such as product price, competitiveness and share price.

Regulations are context specific and need to be arrived at by a process of compromise with those agents involved in the regulatory procedure: the implementors, and monitors, the enforcers, and those subject to the regulations. Without consensus and acceptance of what regulations seek to achieve and how these objectives can be realised, the regulations become costs rather than benefits. Without the recognition of ‘good economics’ and a starting point of the environmental ‘good’, business seeks ways of circumventing regulatory legislation to reduce the costs.

It is with this in mind that regulations should ‘protect’ those who pursue them, without the threat of loss of market share or global competitiveness whilst longer-term environmental strategies are implemented. The relationship between the state regulatory authorities and the business community becomes an important one in this regard - they both must feel that they are working towards long-term environmental goals which will feed back into succesful business activities. To achieve longer-term security for firms engaged in environmental regulation implementation, there is a need for domestic governments to work within multilateral circles in order to create global support networks for firms involved in environmental restructuring. Only in this way can global flows of environmental ‘goods’ (green or eco-products) and ‘bads’ (pollution displacement) be addressed and promoted or curtailed. Sectoral level and product level research is required in order to establish how this can be operationalised effectively.
The Way Forward

Whilst it is end-of-pipe technologies that still provide the primary response to emissions control, there are a limited number of process and production developments that have given rise to reduced emissions and efficiency gains. Future developments in process research may well lead to significant changes in the production system in the early part of the next century as producers attempt to find a way around the emissions from coke and sinter plants (which provide inputs into the steelmaking process), however existing techniques are unproven and are not practical for large volumes of production. A starting point will be improved sampling and analysis standardisation across the steel sector since this does not currently exist.

Although the total impact of the steel industry on the environment is not necessarily great (i.e. 1.6% of total SO₂ [8% of industrial activities] and 1% total NOₓ [7.5% of industrial activities] in the European Union), it is clear that end-of-pipe strategies are reaching their limits. The capture, filtration, and purification processes for air and water emissions are employed almost universally and at high levels of efficiency. The next major stage of emissions reductions (following the likely introduction of stricter standards) will take place in changing the process. Whilst energy concerns (approximately 20% of production costs) and a focus on quality of inputs into the production process will continue to lead to incremental improvements in environmental performance, major improvements in iron and steel environmental performance are as yet still on the drawing board.

The arguments of producers that they have achieved considerable emissions reductions and that they now face higher environmental investments with less environmental performance (a case of diminishing returns) is a valid one, but more than anything this suggests that the current approach to environmental performance, of end-of-pipe systems and very high levels of recycling, is reaching its limits. The next step is one of significant process change that current process technology developments have yet to meet. Best Available Technology advice and promotion will assist in this process but it is not in itself a solution since it remains voluntary and a distinction has to be made between techniques and technologies since the same technology will have differing emissions impacts according to how it is installed and operated, and also according to local conditions - this can be regarded as an important management issue. The industry is aware of the concept of sustainable development and the International Iron and Steel Institute supports the Business Charter for Sustainable Development. The problems lie in how to operationalise the concept, and in this regard in 1992, the president of the IISI stated that the industry should put more effort into the following areas:

* harmonisation of worldwide environmental legislation

* standardisation of environmental management, control and assurance systems

* fostering improved communications and relationships with the media and the general public

* using the LCA to earmark consumer products as ‘environmentally acceptable’

* pursuing the global issue of climate change and the need for energy conservation, bearing in mind the energy intensive nature of the industry

* waste control and disposal, including protection of soils and sediments

* worldwide benefit cost effectiveness of investments in environmental control equipment
There is a need for effective employment of international environmental agreements and regulatory systems around the world if the global market place for steel and other products is to be environmentally ‘levelled’ as a playing field. Whilst the level playing field is an unattainable goal, its pursuit is a worthwhile one in terms of global environmental sustainability.

The role of business, alongside regulatory bodies, in not only formulating regulations but also in implementation of strategies, monitoring and the updating of regulations is critical. Only with accepted frameworks will regulations be effective in achieving the goals of cleaner industries, cleaner products and cleaner environments. To achieve this, business must concede the goal of environmentalism, of environmental ‘benefits’, rather than seeing the environment as a ‘cost’ or a niche market (similar products, different packaging).

Whilst sustainable development requires the environment to be top of the business agenda, it is not. The environment is not central to most firms’ strategy meetings unless it is cited for slowing down production (such as state interventions as a consequence of regulatory breaches), leading licensing red tape, or if there are market advantages, i.e. eco-labelling. Only be stressing that the environment is part of a complex web of strategic factors within a firm can a regulatory framework be accepted, systems implemented and environmental objectives be achieved.