‘Aço Verde’: The Brazilian Steel Industry and Environmental Performance

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ABSTRACT

The Brazilian steel industry dates back to the nineteenth century but the sector was largely developed during the industrial development programmes of Presidents Vargas and Kubitschek during the 1940s and 1950s. Until the 1990s, the steel sector was predominantly state-run, becoming highly inefficient and dated during the authoritarian period (1964-85), but privatisation under the Plano Real has led to modernisation, improved technologies and more efficient management.

In terms of environmental performance, the last ten years have witnessed significant changes in the sector. In response to environmental regulations and greater environmental awareness in industry and amongst stakeholders, steel firms have implemented technological and management responses to reduce emissions and control wastes. This paper stresses that these changes have been positive and successful on the whole, but that greater uniformity in terms of responses amongst firms and in terms of State regulation is required to ensure that the sector as a whole is performing well in terms of reducing its environmental impact. Alongside this uniformity to ensure sectoral environmental performance improvements, there must also be close attention to case-specific details relating to site location, inputs, technologies and business strategy to ensure that all firms continue to innovate and invest in order to reduce total emissions and recycle as much as possible.

Industry and Environment in Brazil[1]

The 1992 UNCED Conference in Rio de Janeiro was not only a recognition of the fact that the 'South' should be given prominence in global environmental terms (whilst recognising that it is the 'North' which is the 'high consumption' area), but a recognition of the centrality that Brazil has had in environmental debates since the 1960s. Against the backdrop of the Amazonian debates and the extensive research which has taken place alongside these debates, on climate change, biodiversity, ecosystem management and socio-ecological disruption, there has also been considerable environmental change taking place in other regions. Whilst the Amazon has been highlighted in terms of unsustainable development and global climatic change, a quite different set of ecological debates have been on the federal agenda since the 1960s with a different set of conceptual issues. These debates refer to industrial development, energy supply and infrastructural development in the States to the south and south-east of the country.

During the first half of the twentieth century, and especially during Brazil's 'economic miracle' of the 1950s and 1960s, the south-east experienced an industrial boom based on the automobile, iron and steel, chemicals and pharmaceuticals industries. The economic triangle (São Paulo-Belo Horizonte-Rio de Janeiro) in the South East continues to act as a magnet for foreign investment and industrial activities and provides the focus for national economic development. The rapid urbanisation process that São Paulo and other southern cities have undergone since the first half of the twentieth century has led to serious environmental and health impacts (see Secretaria da Ciencia, Tecnologia e Desenvolvimento Economico, 1992; Gutberlet, 1996a). These impacts are essentially derived from urban waste contamination, urban transport externalities, resource degradation issues (such as water quality deterioration) and environmental hazards emanating from industrial sources. This 'Brown Agenda' is distinctly different from the predominantly 'Green Agenda' and its causes are generally blamed on poor governance, lack of environmental education and awareness in civil society, and weak economic and regulatory policies. Whilst these causes differ significantly according to cities and regions (due to resource and industrial concentrations, and transport and infrastructural factors), it is the south-east of the country that is experiencing the greatest impacts (see Tables 1 and 2).

Table 1: Potential for Environmental Degradation by Selected Industries, Brazil (1980)[a]

Division	Air Pollution	Water Pollution	Natural Resource Demand	TOTAL
Metallurgy	**3**	**3**	**3**	**9**
Non-metallic minerals	3	3	3	9
Chemicals	3	3	2	8
Paper and cellulose	1	3	3	7

a Based on the Potential Impact Matrix of Magrini (1991), but developed beyond subjectivity with data in the areas of air pollution, water pollution and energy consumption.
Note: Only direct consumption of natural resources are considered. Indirectly related consumption via the productive chain is not included. Greater weighting is given to the consumption of non-renewable resources.
Source: da Gama Torres (1996, 49)

Table 2: Relative Contribution to Industrial Transformation Value by Urban Centres with over 3% of National Intermediate Industries

Centre	TOTAL	Metallurgy	Chemicals	Non-metallic minerals	Paper and cellulose
RM São Paulo	27.6	40.8	21.4	20.5	32.0
RM Rio de Janeiro	6.8	6.2	7.7	6.8	6.5
Campinas[a]	4.4	1.2	10.5	2.2	3.6
RM Belo Horizonte	4.3	7.6	2.1	6.9	-

a Referring to urban agglomeration
Source: IBGE, in da Gama Torres (1996, 56)

The Development of Brazilian Iron and Steel Production

Steel was regarded as a fundamental element of economic modernisation during South America's mid-twentieth century process of import substitution industrialisation, and strategic state steel production plants were established in most of the republics. These plants were large in scale, heavily defended by the State, and production was promoted to the exclusion of environmental impact considerations as steel production became synonymous with the drive towards a more autonomous development model.

From the late nineteenth century, European immigrants had established iron foundries in Brazil. Location decisions were dependent upon iron ore deposits, energy availability, coke versus charcoal decisions and transport issues, but it was the critical nature of raw materials requirements that led to Minas Gerais (MG) State becoming the centre of iron and steel production. From the national development plan promotion of the steel industry in the 1940s, the industry was extended into other States where increasing manufacturing activities required closer sources of steel products. Rio de Janeiro (RJ), São Paulo (SP) and Espirito Santo (ES) all acquired steel production facilities to cater for local demand, better transport links and new employment demands. The construction of the Companhia Siderurgica Nacional (CSN) at Volta Redonda was the jewel in the crown of this expansion, establishing the largest steel production site in Latin America and a focus for the national development model.

In 1955, President Juscelino Kubitschek established the National Development Plan in order to strengthen the Brazilian economy. The State was the sponsor of the Plan and its operations, and this was to continue in the steel sector until the early 1990s. Volta Redonda became the backbone of the Brazilian steel industry and was only challenged from the 1960s when the States of São Paulo and Minas Gerais developed their own major State steel plants. The response was the construction and operation of Cosipa (initially a private sector venture) in Cubatao (SP) in 1962 and Usiminas (MG) in 1963. By 1964, production exceeded national demand for the first time and the sector proceeded to grow in terms of plants, to modernise in terms of productivity, and to diversify in terms of products. This development was overseen by the Steel Industry Consultative Council under its National Steel Plan from 1968, marking a second phase of steel evolution. With assistance from the BNDES (Brazilian National Development Bank) and foreign capital and technology, Cosipa and Usiminas were expanded and when the Steel Plan was revised in 1973, further plants were established (Dantes and Souza Santos, 1994). To coordinate these State steel activities, a holding company - Siderbras - was established in 1973.

All the steel sector developments during this period were characterised by imported technology and technical assistance, and as with other countries around the world, new technologies were introduced relatively swiftly to maximise the efficiency of the steelmaking process, especially with the adoption of the blast oxygen furnace. More recent developments have included increased continuous casting, special steels production, and increased automation of the process. Despite difficulties in the manufacturing of components of the integrated process, and the need to import most state-of-the-art production equipment, the level of process equipment in the leading Brazilian firms is on a par with leading international producers. Currently, production is balanced between integrated production (ironmaking and conversion to steel) using coal and charcoal, and electric arc furnace (EAF) production which converts scrap into steel (see Table 3).

Table 3: The Steel Sector - Installed Capacity

Integrated - 18.4Mt Coal		**Integrated - 4.5Mt Charcoal**	**Semi-integrated (EAF) - 3Mt**
CSN	4.6	Cosigua	Piratini
Usiminas	4.2	Pains	Gerdau
Cosipa	3.9	Acesita	Villares
CST	3.7	Belgo-Minera	Mendes Jr.
Açominas	2.0	Mannesmann	Cofavi
			Dedini

Others - all routes = 2.2Mt
TOTAL production capacity = 28 Mt (1996)

Source: Instituto Brasileiro de Siderurgia (IBS) data, in CSN - General Information 1997

The most significant changes in Brazilian steel organisation came in the early 1990s. The election of Collor de Melo in 1990 brought with it a package of economic and social reforms based on austerity that were continued after his impeachment under the temporary presidency of Itamar Franco. Franco's financial reforms to halt inflation were led by Cardoso who would later be elected president on the back of his success with the national economy. The lynchpin of Brazilian economic stability was the Plano Real. It was based on a new currency (the *real*) and aimed to institute a new era of monetary control in order to avoid the runaway public sector spending which had characterised a succession of previous currencies in the 1980s. The Plan's other essential feature was a privatisation programme which would reduce public sector costs and increase federal revenues from the sales. The steel sector was an early target of the Plan.

The dismantling of Siderbras meant the effective piecemeal selling-off of its constituents, beginning with Usiminas (1991), CST and Acesita (1992) and finally CSN, Cosipa and Açominas (1993); the newly-privatised companies attracted a range of mainly domestic investment.[2] This investment has revitalised the static nature of investment during the 1980s (Pinheiro da Silva, 1992). Prior to privatisation, the steel companies had been managed with political and strategic objectives as well as economic and commercial ones and were beset with problems such as: production lines limited by insufficient inputs; subject to supplier and transport cartelisation; poor labour relations; steel prices indirectly managed by the government via buyer subsidies; and a negative and discredited image with respect to supply times and quality. Post-privatisation, the range of firm objectives has changed considerably in order to modernise in a commercial sense.

Product diversification has become an important issue, with greater emphasis on client service, adding value to products (i.e. painting), and leading with new products such as the CSN two-piece steel can that is being introduced into the Brazilian market. CSN has also increased its galvanised zinc and tinned products as a proportion of total output in order to respond to customer demand and seek a niche within the Brazil automobile sector. Attention to market demand ('verticalisation') is one of the company strategies for the 1990s, alongside increased business opportunities relating to steel due to the privatisation process (shares in raw materials, energy and transport operations for example, such as CSN's 25% ownership of the Ribeirão Grande cement firm to profit from slag by-products), and steel production optimisation (Total Quality Control improvements, technical development, and newer technology such as the mini-mill) (CSN, 1997). Similar strategies throughout the sector have led to significant productivity increases from the pre-privatisation year 1989.

The learning curve was steep following privatisation, requiring reorganisation (such as reducing labour requirements and increasing the efficiency of the remainder), heavy new investment in equipment, tighter controls over costs and new strategies for marketing, sales, and materials and product development. Alongside increasing their own competitiveness as firms, companies and the IBS have been pressurising the government to reduce the obstacles to competitiveness that are present within the Brazilian systems of finance, taxation, tariffs, working practices and infrastructure. These obstacles to Brazilian competitiveness, which are similar for most companies working towards increasing exports and share in the global market, have been labeled as the 'Brazil Cost' (see de Oliveira and Tourinho, 1996). The 'Brazil Cost' is regarded as a calculable addition to the operational and product costs that is in excess of similar costs incurred by competitor firms in other countries. This additional sum is in many ways a hang-over from the State-controlled economy prior to the early 1990s. State control of infrastructure and transport, and the State's use of former nationalised companies to assist in employment absorption, are factors in the existing 'Brazil Cost' and remain despite a slow process of overcoming them. The privatisation process is impacting on this situation since infrastructural, energy and transport activities are moving from public to private hands, and steel firms are involved in buying shares in these newly-privatised entities in order to attain a degree of influence in future developments to keep their basic costs low.[3]

New investments following privatisation have enabled companies to adopt a more aggressive stance relative to expansion and development than in other steel producing countries where capacity is not increasing. The low current steel consumption per capita level (compared regionally and globally) allows considerable scope in this respect. CSN, for example will construct on new mini-mill in Pecém, Ceará, to take advantage of local raw materials and port facilities. Other companies have adopted different strategies dependent on their products and circumstances. CST, which produces steel slabs almost entirely for export (98%), dominates a low price, high volume market, and now holds 18% of the international market, producing the lowest cost liquid steel in the world (see Table 4); the company ranks third amongst Brazilian export companies (behind CVRD and Ford, 1995-96).

Table 4: Comparative Cost of Liquid Steel (no depreciation) - indexed, 1997

CST	100	USA	177
Mexico	134	Germany	185
Rep. Korea	155	Mini-mill	190
Japan	163	(NUCOR, USA)	

Source: CST (1997), based on WSD/Cost Monitor 19 - April 1997

A new post-privatisation emphasis has also emerged in terms of environmental awareness. For CSN, environmental protection is approached within its technical development strategy (1995-2000), taking 6% of the US$1.3 billion allocated. In CST, environmental protection has been included within all three stages of the CST post-privatisation investment stages (1993-2000) totalling US$1723-1823, although there have been indirect gains from more efficient technologies and increased continuous casting (CST, 1997). Most companies have increased environmental expenditure during the 1990s, even those which were private and not part of Siderbras. i.e. the Gerdau Group (1996) which has invested US$46 million on 'eco-efficiency' (industrial water treatment, noise reduction and dust collection systems) in order to reach international environmental parameters.

Environmental Impacts and Production Factors

Guaging the environmental impacts of the steel industry and therefore changes in environmental performance is highly problematic. The problems revolve around monitoring and data collection which vary between companies, the geophysical conditions of the plants, production differences (in terms of raw material and energy mixes, process and output) and the demands from the State regulator. In all company cases, these issues present different problems. Whilst some companies prioritise atmospheric emissions reductions, other companies are resolving particular water discharges or solid waste issues. For each company, investment in and management of these environmental problems is conditional upon regulatory demands, the financial condition of the company (particularly its business cycle), and market and local stakeholder pressures. For these and other reasons, it is not possible to make uniform suggestions that cover all types of process, all types of location, and all moments in time. The issues are complex, therefore responses are also complex. Despite the complexities however, it is possible to highlight the key emissions problems in each medium: atmospheric, water and solid waste.

Atmospheric emissions present the principal problem for companies due to CO2, SOx, NOx and dust. For reasons of regulatory legislation, atmospheric emissions have been focused on since the 1970s and investment has followed this regulatory pressure. The principal technologies employed in atmospheric pollution control are bag filters and electrostatic precipitators, chosen with regard to different stages of the process. Firms make decisions depending on the production system, its age and the circumstances of emissions and local limits. Beyond emissions relating to combustion, further areas of control include particulate materials raised from stockyard raw materials and during transportation. This is especially important for those firms operating in the proximity of residential areas with unsuitable meteorological conditions.[4]

Second to atmospheric emissions, water treatment has been the principal concern of firms although all companies now operate treatment systems. These systems are a mix of physical, chemical and biological treatments for removing or changing the composition of effluent prior to release into waterways. Particularly contaminating effluents that need to be treated include cokery effluent which contains ammonia, gas scrubbing water, water used in rolling mills which can have a high oil content, electrolytic cleaning water, and electrolytic galvanising line water. Different firms have different problems relating to water discharges although for the most part limits can be met relatively easily. For firms operating in inland areas within river catchments, such as CSN and USIMINAS, the water discharges require more control than is the case in coastal sites. In the case of CST for example, the company is located next to the sea and 95% of its water requirements are met from that source; of the remainder, 91% of the freshwater used is recirculated (CST, 1997). Recirculation systems are becoming increasingly common in order to restrict discharge and to reduce costs relating to water intake which is currently in the process of becoming law. Gerdau's Cosigua plant near Rio de Janeiro is constructing a state-of-the-art water processing plant in order to reduce costs that will be incurred with the new legislation, and to ensure that emissions legislation can be achieved without difficulty. For the most part, the technology for water discharge control is standard and has been in place for some time. Any problems are mostly related to maintenance or production difficulties. The ease with which regulators can monitor water discharges, relative to the more difficult monitoring of stacks, often means that this is the easiest target for State inspectors.

Waste recycling, due to the volumes of slags and other by-products emanating from the process, has become an increasing priority of environmental management, and is one which is likely to take over from the atmospherics focus (which in turn had taken over from water treatment from the end of the 1970s). The Brazilian steel industry produces 700kg of waste per tonne of steel, and waste recycling runs at 62%. Some companies, for various reasons, have been able to improve upon these figures: CST produces only 570kg/t, and recycles 91%, of which 52% is sold commercially, 39% is recycled, and 9% is stored in landfills (Maumédio de Paulo, 1992; CST, 1997). USIMINAS is typical of other integrated plants in its solid residuals programme (Table 5 - USIMINAS, 1996):

Table 5: Solid Waste Management at USIMINAS

Residuals Generated **100%**
Recycled Unprocessed in Sinterplant ***48%***
incl. blast furnace dust and wastes, steelmaking dust and wastes, raw material fines
Commercialised ***40%***
blast furnace slag to ceramic and cement industries, limestone waste for agricultural use
Controlled landfill disposal ***12%***
Class I 2% (oils)
Classes II/III 10% (refractories, steelmaking slags, acid neutralised waste, blast furnace slag, industrial waste)

The recycling of wastes, and how these by-products can be used effectively as inputs in construction and for other purposes is presently a source for considerable research interest in universities and the larger firms; Brazil's roadbuilding programme is an obvious outlet for these by-products. Any products that cannot be sold or recycled through the combustion elements of the iron and steel process, are landfilled. Class I category materials are hazardous but for the most part, integrated plant by-products are non-toxic and are disposed of cheaply. Whilst many firms have been significant strides in the direction of sales of by-products, or of reuse and recycling within the plant, there are wide variations in terms of development in this area. The IBS is pressurising the federal environment body CONAMA to make more by-products suitable for recycling and sale. The impetus behind this is the increasing cost of landfill and the management issues related to its storage on site due to its sheer volume, or in terms of toxicity in the case of oils.

Taking the steel company activities further upstream, it has to be recognised that they are prolific energy consumers, therefore changes in their energy demand will have significant impacts in terms of types and sources, each with particular environmental impacts. All steel companies are proactive in reducing their energy demand for primarily cost-based reasons, however the environmental impacts of these decisions regarding energy mix are also positive ones. In the case of CSN, the development of a 235MW thermoelectric plant to take advantage of gases generated in the steel process is an important step towards recycling energy at the plant level. Other elements of their energy programme revolve around participation in hydroelectric developments (at Itá and Igarapava). CST has also focused on gases reutilisation (coke oven gas and BF gas), alongside producing 100% of its own energy (150MW) which will be increased by 120MW with a new power plant (CST, 1997). Other companies are also seeking greater energy security alongside reducing consumption via recycling technologies. In terms of energy consumption per ton of steel produced, Brazil lags behind other producers, however the increasing application of continuous casting and the aforementioned technologies should maintain a continuing downwards trend to compete with other international producers (see Table 6).

Besides the important issue of energy use, there is an element of steel production that is particular to the Brazilian case in terms of scale - the use of charcoal to replace coal. A negative element of Brazilian production is the lack of suitable coal deposits and under the State-administered years of the industry, coal from the country's southernmost States was used in large quantities, however this material was high in sulphur and low in efficiency. The result for steel production was environmental contamination and inefficiency in the process but since the government sought a more autonomous development model with the use of domestic resources, firms were compelled to take advantage of this raw material. In the 1990s, most coal is imported which is better for production and for the environment.

Table 6: Gigajoule per ton of steel produced (average)

Brazil	24.9	France	20.0
(CST	20.1)	Japan	18.1
USA	20.1	Germany	17.6

Source: CST - Environmental Profile, based on International Iron and Steel Institute (IISI) 1996 data

Traditionally Brazil has profited from its abundant natural resources, especially forestry, in order to provide cheap inputs into the steel process - for those steel firms using charcoal, this input accounts for 70% of the total cost of raw steel (Medeiros, 1995). For these reasons, the production of charcoal from managed forests is still an important source of raw material for several firms. These firms manage large tracts of sustainable forest, principally using eucalyptus species which grow quickly and have the right properties to make good quality charcoal (Mannesmann Florestal Ltda., 1996).

The environmental impacts of charcoal use in steel production relate to the native forest loss and replacement with homogenous, exotic species, also the impacts of the charcoal production process, also transport of the material and its final use. Despite criticisms, many large firms have developed R&D programmes to establish sustainable inputs into their production systems. These large steel firms have generated respectable charcoal operations and must be contrasted with the practices of many *guseiros* - small-scale pig iron producers With extensive investment in this source of raw materials, it is unlikely that charcoal will disappear from steel production in the medium-term. The principal issue is what balance of exotic versus native species is sustainable in particular areas, and what regulatory limits should be put on the extent of production.

Regulatory Management

The government agencies in charge of environmental regulations and their implementation vary according to States and their economic activities. Resources, styles of monitoring and enforcement, and environmental performance strategies differ across State boundaries with the result that production sites with similar environmental impacts can be treated differently within the national territory. The outcome is that the location of industrial sites is becoming increasingly responsive to environmental regulations and their enforcement in different States. Since competitiveness and production costs now include the actual and potential penalties for compliance failure and responding to regulatory demands, firms are becoming more analytical of regulatory legislation, organisations and effectiveness. Whilst States operate different regulatory systems and differ in terms of flexibility, they effectively provide incentives and negative signals in terms of environmental controls over industry (see Neder, 1996).

In Brazil, the regulatory bodies of the south-east lead the country's other States in terms of efficiency, organisation and resourcing. Within this region there are also significant differences. São Paulo State provides the leading model for Brazilian environmental control. The industrial concentration of the State has demanded the establishment of a large agency (CETESB) in terms of personnel and resources in national terms, which has adapted significantly since its inception as a water treatment laboratory thirty years ago (see Philippi, 1992; Crespo, 1993). Rio de Janeiro State (FEEMA) and Minas Gerais State (FEAM) have less burgeoning industrial sectors but still have significant, large-scale activities which are potentially polluting. The State of Espírito Santo is a small State with a smaller number of industrial operations, although CST and CVRD are important national companies which are located close to the State capital of Vitória and create a high degree of environmental concern. The separation of Federal and State regulations has played an important role in industrial development. Whilst Federal regulations provide a minimum framework for environmental performance, States have the legal authority to enforce stricter limits and requirements.

Regulations with respect to the steel companies have in most instances been instituted within agreements - *Termos de Compromisso* - whereby the regulator and the firm have identified long-term programmes of priorities and investments.[5] This approach has been common during the 1990s and has been successful due to the environment investment programmes of the privatised companies. The agreement identifies a time span for environmental improvements, specifying responsibilities, investments and actions, regularity and efficiency of equipment and the on-going costs of monitoring and maintenance. The benefits to the company are greater flexibility in terms of the relationship with the regulator (although the agreed plan must be followed), and increased involvement in the development of legislation and environmental planning (via closer contact with the regulatory organisation, and at the State and Federal level through industrial associations).

Whilst leading companies are taken positive steps towards environmental management and the meeting of emissions targets, other companies have struggled to invest in these systems. Even amongst the large companies there is criticism. FEEMA remains critical of CSN and its environmental performance whilst Cosipa in Sao Paulo State (Cubatão) still has a long way to go before CETESB will reduce its high level of pressure on the firm; the highly political - in environmental terms - industrial area of Cubatão is the reason for this (see Fornari, 1991; Gutberlet, 1996b). In these two cases there is apparent disagreement between regulators and firms in terms of their environmental achievements and current performances. The difference between the two cases is that FEEMA continues to struggle against low resources - which impedes inspections - whilst Cosipa is inspected very regularly by the area branch of CETESB.

A further difference is that penalties levied against CSN have been effectively returned to the firm for assistance with *Termo de Compromisso* objectives, whilst Cosipa receives none of its fines for tied investment. Whilst in Sao Paulo State fines are returned to the State treasury, it is the only State with a finance initiative for environmental technology investment (PROCOP) (see Mello, 1990). The initiative is small-scale but is a step in the direction of greater flexibility by CETESB, away from the sole role of regulatory enforcement towards cooperation, incentives and motivation. These two examples reflect the differences in attitude towards environmental control and resourcing in two States. In the case of Minas Gerais, a regulatory team focusing exclusively on ferrous metallurgy appear to have a strong relationship with industry and firms have responded well, for example USIMINAS and Acesita.

An effective regulatory system is dependent on legal support and a penalty system that creates a deterrent for companies whilst at the same time encouraging them to institute innovative practices and modern technologies. There is little evidence in Brazil that the existing judicial and penalty system functions as a deterrent - penalties are not common and certainly do not affect firm competitiveness to any degree. The reasons for this are numerous, however they all point to a similar failure - firms are more concerned with other factors of production and consider environmental fines as small enough to be incorporated without significant financial burden. Until this balance is altered in favour of the regulator, via stiffer penalties and political support to use heavier sanctions against industry such as suspension of production and closure, the contrasting experiences of firms will continue. In order to achieve this, there must be federal agreement to ensure that there is no risk of inter-State pollution haven tendencies

Generally speaking, the relationship between regulators and industry has not been a good one. Much of this lies in the background of the heavy industries during the 1960s and 1970s under the authoritarian administrations. As defended, strategic industries they had to respond very little to demands for environmental control. This situation changed rapidly during the 1980s due to international environmental awareness and the need to comply with new, more demanding legislation. Still, the traditional criticism was that the regulators were anti-developmentalist, concerned only about pollution control rather than the social and economic issues associated with the changes, and inflexible. In return, the regulators believed that the industries were unlikely to adopt major environmental protection and control measures without strong State pressure and penalty systems.

The changes of the 1990s, with privatisation, opportunities for establishing *Termos de Compromisso* and greater environmental awareness within the industries (in terms of community, markets and legislation), have ushered-in a new wave of regulation that has sought more flexibility where possible, and greater cooperation and assistance. This has been possible in most cases, but command-and-control has still been necessary where companies have been slow, or intransigent, in implementing necessary changes. The IBS (1990) argues that the steel industry has passed through four phases with respect to regulation: negation of the problem; reactive negotiation; tendency to cooperate and a proactive attitude; and the modern approach to accept the need to protect the environment. Different companies are at different stages but the leading companies are increasingly aware of the need to reach stage four to be internationally competitive, hence the widespread application of ISO 14.000.

Company Environmental Management

Environmental management requires a range of skills, technologies and programmes: procedures must be defined; management systems put in place; technology controls established; modernisation of existing equipment promoted; pollution control and operational efficiency optimised; accidents prevented and controlled; and green areas developed, monitored and maintained (IBS, 1990; 1995). It is a relatively new area of management expertise in Brazil and elsewhere following the technological advances in the 1980s in pursuit of improved environmental performance. In the 1990s, more emphasis has been given to establishing environmental management systems, departments and personnel to oversee implementation, monitoring (including audit and evaluation) and effective environmental public relations and education. The introduction ISO 14.000 has also provided an important target for firms, especially those involved in international trade; for others focusing on the domestic market, Gerdau for example, ISO 14.000 has not been prioritised. Gerdau's Cosigua plant is focused on best available technologies to achieve its environmental objectives and has not invested in environmental management teams.

Ronaldo Campos Soares (1990), president of USIMINAS, sums up the three pillars of environmental management as: integation with regulators, relations with the community and management within the company. With this strategy, applied early on in the Brazilian context, USIMINAS has been a leader in industrial environmental management; as early as 1979, technical assistance on environmental control was organised with Nippon Steel. To stay ahead of regulators and competitors in environmental affairs, USIMINAS has clear stated objectives and associated action plans that go beyond more basic technological installation intentions towards reduction targets. These objectives are mirrored by other leading companies who have environmental statements, strategies and targets. Although aims are typically wide-ranging, the USIMINAS example of detailed targets for reaching stated objectives (as above) is not common and points to a more practical concept of environmental policy declarations.[6]

Within CSN, the environmental management system has four areas: an environmental management system (written procedures integrated with productive areas); monitoring (to ensure compliance with existing legislation); policies (emphasising the company's objectives relating to the environment); and institutional strategies (actions connected with government organisations in order to influence situations which affect the company). Measures have been focused on priority areas such as particulate matter emissions from stacks, particulates in suspension in the air (around the plant and in the city), and measurement of effluents (especially pH, temperature, cyanide, phenols, ammonia, BOD, and heavy metals) in water treatment and quality stations for the Paraíba do Sul river (Metais e Materiais, July 1997).

Almeida e Silva (1995) notes the benefits accruing from the CST environmental policy: a 90% atmospheric emissions reduction (1990-94); US$26 million saved by recycling and consequent reduced waste volumes; water recirculation of 91%; and reuse of gases for 90% of electrical energy production. These targets have been met from changes initiated by management directives led by the Business Council for Sustainable Development. Following their guidelines, the company has policies within the company (compliance, auditing, EMS improvements, education) and external to the company (community dialogue, information dissemination, R&D cooperation). Much of the early work on CST environmental organisation was developed along the lines of the British Standard 7750. Almeida e Silva (1995) concludes his paper on the company's environmental management by stating that it is necessary to change environmental management with a perspective on the costs that it implies, for environmental management to have a business perspective, that demands a positive cost-benefit balance and provides the company with competitive advantages in the market. Cosipa (1997) has invested in the environment in the form of its PAC (Projectos Ambientais Cosipa) fund, set up from the beginning of 1997, which has invested US$160 million in pollution control (23% of a total investment plan of US$ 691 million).[7]

Although companies are keen to point out their environmental developments and increased awareness, there are still areas of concern in most plants in terms of the need to control certain processes or to drive down emissions levels. On the one hand, credit must be given to companies to their high levels of investment in environmental controls since privatisation, yet on the other hand the low starting point of the 1980s reveals that this investment was both late and necessary. Although environmental management has had important impacts, the rhetoric of company documentation and claims and the realities of emissions levels have to be considered in detail to determine actual environmental performances. The regulators are best placed to make these judgements and they clearly feel that more can and should be done, providing continuing pressure on firms to invest more and manage environmental problems better, both in a supportive way and with 'big stick' as necessary. Various management areas have been highlighted for greater attention, with positive results on the whole: training and personnel development; environmental management systems; audit and accounting; and greening and community programmes.

Training of personnel and the organisation of environmental teams and department varies between firms. The recent nature of environmental developments has led to a range of company experiences in this regard, from fully fledged environment departments to smaller environmental sub-departments and the decentralisation of environmental responsibilities to facility level. The important element is the integration of technological and management approaches to the environment. Since there are cost restrictions for environment spending as with any other area of production, there is a need to maximise existing equipment capacity to ensure optimal efficiency in its operation; this requires effective management of the environmental equipment and the training of personnel operating and inspecting the equipment. Many companies have linked environment with other areas such as health and safety, i.e. Cosipa in its Superintendency for Medicine, Worker Safety and Environment, whilst others have a discrete division. USIMINAS for example has a sophisticated structure for environmental management which includes personnel with environmental training and attentive to environmental performance in the department of Management for Environment and Urbanism, in Production Management, also an Environment Group and personnel in the Laboratory of Utilities and Environmental Control. The structure seeks to integrate environment and production managers and operatives in order to achieve a concerted effort of environmental control throughout the process (USIMINAS, n.d.).

CSN has a programme as part of its environmental management that transcends the company hierarchy, and also includes the local community with an environmental education programme that started in 1997. The existing Quality Control Circles (CCQs) set up for ISO 9.000 to deal with localised problems have also been utilised to deal with environmental issues. Cosipa (1997) defines in its environmental management summary that 1.400 employees were trained in 1996, in the Programme of Qualification and Training of Company and Contracted Personnel.

Environmental training was incorporated in 1996. Experiences are varied although it is clear that training is increasing and is now being incorporated at all levels within the companies. It may take some time before a change in attitude towards the environment filters down to workers throughout the site but environmental managers appear to be convinced that once this takes place, energy savings and greater environmental risk awareness will be both economically beneficial and will reduce accidents.

The key environmental management tool that staff have been trained to put in place during the last two years has been ISO 14.000. Environmental Management Systems (EMS) have become central to most companies in terms of environmental protection and control. Ronaldo Campos Soares, President of USIMINAS, describes it as follows (USIMINAS, 1997):

The objective of USIMINAS, with the prioritisation of EMS, is to attain environmental excellence, by achieving legislative compliance and concentrating on principles of sustainable development via proactive environmental responsibility.

The ISO 14.000 norms that were established in March 1993 by the ISO Technical Committee TC-207 have had a significant impact within Brazil.[8] The steel sector is no different in this respect, following on from the rapid take-up of the ISO 9000 quality certification from the mid-1980s. The principal driver for the take-up of environmental management outlined by ISO 14.000 has been the factor of international markets and the uncertainty about how ISO 14.000 might be employed in the future in order to restrict free trade, or in terms of consumer awareness and the pressures that this would have on steel customers to reveal competent, upstream environmental management (see Centro Brasileiro da Qualidade, Seguranca e Productividade, 1994; Claudio, 1994; Cetesb, 1995). USIMINAS cite many 'Advantages and Opportunities' associated with certification (USIMINAS 1997, n.d.):

* rationalisation of human, physical and financial resources
* legal security
* competitive advantage of preservation and expansion of markets
* pro-active posture regarding regulators and community
* reduction of costs and increased productivity
* access to lines of credit
* reduction of insurance premiums
* prevention and control of accidents and losses
* revitalisation of the Quality Guarantee System
* increased environmental consciousness
* market advantage via company image

Although USIMINAS is the only steel company to be accredited, (amongst a limited number throughout the country), others are going through the initial steps towards accreditation, such as auditing and the construction of systems and procedures. For the most part, the leading steel companies regard accreditation as an effective market tool as well as reducing their environmental costs in the longer term. For example, CSN is adopting ISO 14.000 in order to improve its environmental procedures with regard to meeting a market with an increasing environmental awareness, and also serving neighbouring communities and employees (Metais e Materiais, July 1997). The citing of local communities and their environmental complaints appears to be a further important stimulus for firms. In this regard, the image of the firm is becoming important and the desire to reduce conflict with ‘stakeholders’ (whether neighbours or shareholders) is apparent.

A key to environmental management and the introduction of ISO norms is the ability to cost such management investments and their effectiveness. The concept of a ‘Pollution Cost System’ (Maciel, 1993) is still underdeveloped in Brazil, as it is in Europe. The consideration of pollution costs as a factor in production cost reduction and greater efficiency are gaining ground slowly although the difficulties associated with identifying and calculating specifically environmental costs, apart from production and labour costs, are problematic. Effective accounting is itself dependent on monitoring strategies, systems and equipment to undertake this function effectively. The by-products generated by the production process are perhaps the easiest to monitor and calculate due to their volume and composition and the costs of dumping and reprocessing these by-products. Maintenance costs refer to the upkeep of environmental technologies and environmental management which can vary widely by firm, especially where preventive strategies are in operation rather than purely maintenance of end-of-pipe systems. Depreciation of environmental technologies and also deterioration of production technologies which may lead to reduced efficiency and greater contamination should also be factored in. Only with these types of calculations will it be possible to contest arguments, such as those of Porter and van der Linde, that there may be a ‘win-win’ situation in terms of market advantages and overall benefits resulting from environmental control.[9]

Changes in legislation imply new costs which add to existing demands and costs and require constant attention. At the Federal level, such as current water-charging regulations that will come into force in the next two years, companies have to fulfil national obligations that are not sector or firm specific; water legislation includes the organisation of Catchment Agencies and Committees. At the State level, environmental performance demands are generally written into the *Termos de Compromisso* of State regulators and firms and can require extensive investment programmes over longer timescales. These costs can be accounted for easily in terms of additional technologies and associated labour and energy needs.

Further costs relating to legislation are those incurred in penalties and compliance failure. In the context of pollution costs, these are often the most damaging since capital is lost to the State and cannot be invested in improvements; the case of CSN is different in this context. Unlike other steel firms, CSN has benefitted from a highly flexible system of regulatory penalties applied by FEEMA. CSN penalties incurred from environmental degradation have to be invested in improved environmental control. Whilst on the one hand this appears to be a positive regulatory approach in order to achieve improved environmental performance, the other hand reveals the under-resourcing of FEEMA and its inability to function as an effective regulatory body and to implement environmental legislation, also the fact that other groups (i.e. nearby residents affected by atmospheric pollution, and other water users) are not beneficiaries of the polluter pays model and suffer from the externalities of the firm with little State assistance.

An associated element of the accounting system is effective auditing and most companies have been moving forward in this direction. Environmental auditing is usually sought outside the firm. In Brazil, the consultancy of Arthur D. Little has been influential throughout the sector. Cosipa contracted the services of the Arthur D. Little company to establish a systematic environmental audit - the first two audits were carried out in 1995, and are used in determining development plans for environmental policy (Cosipa, 1997). In the case of CST, at the initial stages of auditing, advice also came from Paul de Backer (international Eco-Auditor), KPMG in Holland, ABES and its consultant Ricardo Kohn, a specialist in UFES, and experts linked with CVRD. Audits have come in response to legislation - in the case of CST, operational from August 1996 in Espirito Santo State. The legislation requires three audits in three years, plus occasional audits from the State regulator as it sees fit. The outcome of the audit is required by law to be published in a major newspaper as a so-called ‘Environmental Declaration’. The State regulation follows from the local Vitoria municipality regulation (1993) which requested two audits in a two year period, similar to Federal regulations (1992) (Freitas Alvim and Morimoto, 1995).

Apart from compliance, auditing has enabled companies to target areas for resource prioritisation and corrective action. For CST, one of the reasons for environmental audit was declared to be: “To recognise the competitive importance and character of environmental management, and consequently of the environmental audit.” Upper level management support is considered to be vital to the effectiveness of environmental audit. Also of considerable importance is the training of internal company auditors (with external assistance). The documentation for environmental audit falls into the categories of the Audit System, the protocol for verification, and responses (Freitas Alvim and Morimoto 1995). Although in its infancy within the steel sector internationally, approximations currently serve as useful indicators, and IBS is moving in this direction within its Environment Committee.

Beyond these cost-benefit considerations and production-related approaches, there is a strand of environmental management that is largely externally-oriented - these may be termed ‘greening and community programmes’. The IBS (1990, 25) puts it in the following terms

> The company must emphasise that it is conscious of its social responsibility and is preoccupied with promoting and harmonising the aspects linked with this responsibility, such as development and environmental protection.

There has been a recognition of the need to establish industy-community links in terms of environment since the 1980s. In an Industry Environmental Administration Seminar in Rio de Janeiro in August 1988 for example, industry-community issues were highlighted alongside industry-regulator integration and internal environmental management. The IBS also concedes that often the positive effects of industries are often national whilst the negative effects can often be concentrated locally, whether as a result of normal industrial operation or emergency incidents. For this reason, communication channels are essential. This may be especially important for large firms operating alongside large urban areas where traditional community links have broken down - employees are important channels in this respect (IBS, 1990; 1995).

Mechanisms for increasing industry-community links are numerous, including: local newspaper information; company-residents meetings; schools visits and competitions; and tree planting. In many ways, the mechanisms seek to promote positive elements of environmental change rather than negative elements that are circulated within the community and by NGOs and critical media. Whilst these are on-going processes of information dissemination, emergency incidents require immediate reaction and procedures for not only the control of the pollution event but also of information circulation. Some firms have 'hotline' phone numbers in order to respond to concerns from the surrounding communities, and also have procedures to relate information via the media.[10]

USIMINAS has one of the longest-established environmental education programmes in the country. Projeto Xerimbabo is an adult and children's environmental education programme that is linked with the company's own Zoobotanic Park and has been running for twelve years. The social communications department is also important in this regard. The awarding of ISO 14.000 was a further step towards this company commitment, the culmination of US$ 350 million of environmental protection investment. CSN has developed a monitoring strategy for the city of Volta Redonda due to the proximity of the residential area, and it also has an area of 131 hectares which is protected by federal legislation. A site greening policy has led to the planting of 75.000 trees, 231.000 bushes, increasing the green area to 443.000 m3 (Metais e Materiais, July 1997). Cosipa has achieved 17m2/employee of green area, resulting from its planting programme (the WHO recommends 12m2/employee) (Cosipa, 1997). However, Cosipa's real problems lie in controlling its emissions, especially since it is located in such a sensitive area.[11]

In terms of community developments, there is a strong development of government-university-company networks. In the case of CST for example, there has been collaboration with the Federal University of Espírito Santo in the area of industrial development (see Morandi, 1995) and environmental control (see Guimarães, 1996). The establishment of the COEG (Organising Commission of Government Institutions) to link together municipal organisations and the State regulator in Vitória in order to oversee the fulfilment of the *Termos de Compromisso* of the two principal companies in the area (responsible for 90% of the atmospheric contamination of Greater Vitória): CST and CVRD (Companhia Vale do Rio Doce) is an example of this. The COEG is able to communicate developments to the public via meetings and seminars. Universities and research institutes have also been conducting important work on environmental impacts, recycling and environmental technologies, as well as instructing the next generation of environmental engineers and managers. Federal University, Vitória, projects have included (Guimarães, 1996): electrostatic precipitator efficiency; civil construction slag uses; atmospheric gas dispersion modelling, and the use of bioindicators for heavy metals monitoring.

For Brazilian companies to remain compliant with environmental legislation, they have had to effect numerous environmental systems which have had many benefits. These have included auditing, training, improved environmental management, increases in management and worker environmental consciousness, equipment maintenance prioritisation, establishment of 'environment' in the area of operational control, anticipation of regulatory visit problems, improved environment-operational personnel communications, full legislative compliance, and the opportunity to receive environmental certification. This range of issues has hastened the need for strong environmental management teams working across a range of tasks. As legislation, consumers and pressure groups become steadily more demanding, the role of the environmental manager will become more demanding and more central to the day-to-day functioning of the firms. Perhaps at that moment, environmental accounting systems will also be operational to calculate the costs and benefits of such personnel and their management choices.

Whilst management issues are increasingly important within company strategy relating to the environment, the technological approach to environmental control remains central. Investments in environmental performance improvements have been substantial since privatisation following a gradual rise during the 1980s. However this investment is now stabilising. This has mainly been due to the relative lack of investment prior to this point from a starting point in the 1980s. Throughout the globalised steel industry, those firms which are more recent and were constructed with environmental technologies in place have gained considerable advantages over those older facilities which require retrofitting and upgrading. The costs entailed in the environmental improvement of older process technologies are considerable due to issues of space availability, physical interference, and facility shutdown to allow installation (IBS, 1990; 1995). This has been a problem for most Brazilian firms.

Since its founding in the early 1940s, CSN has invested US$200 million in environmental prevention and control, divided between US$105 million - air, US$75 million - water, and the remainder in landfilling and noise control. Of this figure, US$60 million has/will be invested between 1994-99 (Metais e Materiais, July 1997). CST invested US$231 million during construction (1983), US$119 million as ongoing capital expenditure, and US$55 million in new investments. The high investment of the post-privatisation years have found its way not only into process technologies but also environmental technologies. CSN, for example, has invested US$14million in dust emissions reductions by installing sinterisation plant electrostatic precipitators (increase of 6t/day of dust captured). It must also be pointed out that the process technologies have also led to environmental performance improvements, such as increased continuous casting and the installation of PCI (pulverised carbon injection).[12] The recognition that effective environmental management puts emphasis on process technologies, input selection, and human resource management rather than purely on end-of-pipe systems is now widely recognised by environmental managers throughout the sector. However, investments in capture systems are likely to remain high until innovative strategies can be developed and are supported by top management.

Issues for Consideration

1. State of the Steel Sector

Brazil's steel sector is expanding and modernising due to the new investment that has arrived with the privatisation of the early 1990s. The 1990s sector provides a stark contrast with the sector of the 1980s when investment increased very little, companies were still tied to political objectives (such as regional development and employment) and productivity and per unit steel costs were not internationally competitive. Privatisation has provided an impetus to the sector to move ahead on several fronts, such as price competitiveness, rationalisation of production, product development, quality, raw material and energy supply security, and also environmental investment and management. These changes have been costly to the firms in question but there are factors which suggest that the investments are sound ones: Brazilian steel is highly cost competitive on the international market - particular CST's products; low current steel consumption leads analysts to suggest that capacity can be expanded (bucking the general trend in international steel production); and environmental investments raise company profiles, protect 'stakeholders' such as workers and neighbouring communities, and improve market opportunities (the impetus for ISO 14.000 implementation).

Total investments in the sector continue to rise although environmental investments are now stabilising following intensive investment in the early privatisation years; it would appear that environmental protection will hover at approximately 6% of all investments in order to modernise the sector in Brazil to the end of the century. Despite this consolidation phase, the outlook for the sector is a good. Although the international market is competitive at the moment, advantages in labour costs (although not in labour productivity necessarily) and raw material availability (particularly iron ore, and charcoal for some firms) provide the sector with a strong competitive basis.

2. Environmental Impacts

Environmental impacts from the steel sector are widely known and have been criticised for a long period of time. What is clear is that these impacts have been reduced significantly since the 1970s with advances in technology. Brazilian steel firms have had technical cooperation with other international companies for many years, they purchase equipment on the international market, and they are aware of the impacts, the emissions reduction technologies, and the pros and cons of installation and maintenance.

The obstacles to reducing environmental impacts revolve around company priorities and investment strategies. Whilst regulators and legislation have impacts in terms of determining which media are important - highlighting water and air for instance, the penalties in Brazil would appear not to be sufficient deterrents for firms. The cases of CSN and Cosipa are examples where firms have been slow to meet regulatory demands, choosing to invest in other production areas rather than environmental protection. Rather more than absolute levels of impacts, of greater significance is the rate or trend of reduction of contamination in case specific instances. These reductions need to be encapsulated within a notion of environmental performance. Steel firms in Brazil are on a downwards trend but there are wide variations across firms and there is clearly a problem in terms of good monitoring and assessment. Since regulators utilise firm data - with an independent check once a year on average - comparative data across firms would be useful to compare performances and where gains have been made. Firms should be given credit for rapid environmental developments since the 1990s but the starting point was a low one and considerable work remains to be done. It is imperative that support for impact reductions come from executive directors - as in the case of USIMINAS - and that there is a strong working relationship with regulators to achieve clearly defined targets.

3. Regulations and Regulators

Beyond the commonality of Federal environmental policy, there are wide variations between State regulatory agencies in Brazil. Different States have significantly different problems, ranging from the industrial concentration problems of São Paulo State across a range of manufacturing sectors to the specific metallurgy and mining issues within Minas Gerais. Resources for agencies also vary according to State funding and prioritisation. It is clear in the case of Rio de Janeiro State for example that there is a clear funding problem since inspections cannot be carried out as scheduled, also that the State has a strategy to generate as much foreign direct investment as possible (with possibly detrimental environmental consequences).

Despite this criticism of FEEMA, this agency also reveals the range of strategies that are in operation around the country to confront industrial contamination issues. It is currently developing its regulatory policy on a catchment basis, working with all stakeholders within the catchment in order to reduce emissions and reach negotiated settlements. Other strategies include CETESB's Procop finance support for environmental technology innovations, also FEAM's specialised steel team. Each agency reflects the context of industry within its boundaries and the issues that are most critical, however it is apparent that resourcing problems exist and high levels of technical expertise are still required in order to provide a better balance between firms and the environmental regulators. As environmental policy becomes gradually tighter at Federal and State level, and as environmental consciousness increases within the country (prompted by the Rio Summit for example), the balance may well shift in favour of the regulators but steel firms remain influential both politically and economically.

4. Environmental Management and Technological Change

Two of the major shifts in the Brazilian steel industry in recent times have been in production technology - such as continuous casting - and environmental management initiatives. Apart from the recognition of the need to be competitive in terms of price and quality, investment in state-of-the-art technology and environmental management have been notable developments. The production technology advances such as continuous casting and the recycling of production gases for energy savings have had positive environmental and cost benefits, therefore there has been a slight shift towards process and production methods and not solely on end-of-pipe systems. Since these technological developments are widely available and applied throughout the world, the environmental benefits are not always considered discretely therefore the 'cleaner production' concept is not applied, despite that fact that they fit the bill very well.

Beyond production technologies, it is in the area of environmental management that most recent progress has taken place. The realisation - whether true or not - that environmental issues may lead to trade barriers (direct or indirect), and the need to work with stakeholders to improve local environments (for PR and moral reasons) has led to many initiatives in order to improve environmental performance. The enthusiasm for ISO 14.000 amongst steel companies is evident and it is apparent that significant progress is taking place in systematisation, management structures and procedures, and awareness via training. A major caveat is that ISO 14.000 does not guarantee environmental performance improvements. For these to take place, regulators and firms must audit processes and reach agreed and practicable targets. These are evident in the *Termos de Compromisso*, however the penalties for not meeting agreed targets must also be evident and effective. It is not clear that they are in most instances in Brazil, a legacy of former years when the State and the steel sector worked hand in hand towards national development goals.

The final consideration that must be highlighted is that there have been two distinct phases of sectoral development. Pre-privatisation one can say that companies polluted freely in the pursuit of high output figures. Post-privatisation, the environment has been emphasised as a strategy alongside the priorities of modernisation and increased competitiveness. Whilst some companies have moved ahead rapidly in terms of environmental management and technology, other companies have lagged behind but are still investing. Nevertheless, the gap between the environmental performance of Brazil's steel companies and other international companies is less perceptible now than in 1993. Despite improvements however, there are considerable variations between companies and that there is still a long way to go for steel companies to reduce their energy consumption (in terms of upstream environmental pressures) and their emissions to the point that all emissions are minimised to levels where human and natural impacts are manageable and sustainable, and by-products are effectively recycled or disposed of. Firms have embarked on a process of environmental awareness that will require continuous management and technological changes during the next decade. The State, communities and markets will drive this process but it is only via cooperation and realistic objectives that the sector will be able to incorporate environmental considerations alongside production and commercial considerations. The task is a complex one, but one which will have far-reaching consequences for human health, the natural environment and economic development in the long-term.

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Notes

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[2] In 1997 CSN's principal shareholders were the Vicunha group (14.3%), Bradesco (10.9%), PREVI (10.5%), Docenave (9.9%), Caixa Beneficente da CSN (CBS) (9.8%) and the Clube de Investimentos da CSN (9.2%). CST's principal shareholders were Acesita (29.3%), CVRD (22.7%), and Japanese shareholders (10.3%) (CSN, 1997; CST, 1997).

[3] CSN envisages that electric energy can be supplied at 40% less per kWh than at present, that raw materials railway transport costs need to be cut by 15% and that 30% lower port handling costs should be targeted. Currently 75% of CSN's total transport costs are generated by the movement of 7MMt of iron ore and 3MMt of coal and coke annually by rail; CSN now own 12.5% of the Centre-East rail system and 20% of the South-East rail system, totaling R$625 million of investment in the five years since privatisation. In terms of port facilities, CSN is the principal user of the ports of Sepetiba (95% of volume handled - coal and coke imports) and Angra dos Reis (product exports) and wishes to reduce costs whilst at the same time increase productivity and reduce supply interruption risks. In terms of raw materials, the privatisation of CVRD gave CSN the opportunity to ensure iron ore supply security and the company became a partner in the VALEPAR consortium (also PREVI, PETRUS, Nations Bank, Opportunity) that purchased the company for R$3.3 billion; CSN holds 41.73% of the shares.

[4] As a significant contributor to atmospheric contamination in the Greater Vitória region (with its neighbour, CVRD), CST has sought to reduce its emissions and meet legal norms. Cooperation with a local municipality agency and the State university has been important in this development (CST, 1997).

[5] CSN signed an agreement with FEEMA (the Rio de Janeiro regulatory agency) in 1994 to resolve its environmental problems before May 1994. The agreement included 325 items The company claims that 80% of the items in the agreement have already been achieved. For CST, the Termo de Compromisso was drawn up in September 1990, outlining 40 items which had to be accomplished by 1994. In October 1994, 45 more items were added in order to continue the environmental performance improvements process (Guimarães, 1996). CST invested US$60 million to achieve the 1994 demands. For USIMINAS, the Termo de Compromisso with COPAM (Minas Gerais regulatory agency) of 1990 had the objective of instituting adequate operational facilities to meet environmental regulations. This was renegotiated in 1994 and 1996 with 37 actions to be undertaken with an associated cost of over US$ 170 million (USIMINAS, 1996b).

[6] *Policy Statement/Declarations of USIMINAS*: to preserve the environment with the best ecological techniques; to assist in the development of state pollution control policies; to improve the quality of life of the worker and his/her family; to manage and control the environment in a participative way; to develop a green areas programme; to improve awareness of the environment in workers and their families; to utilise human resources and materials to achieve the efficient management of environmental programmes and projects; to maintain polluting emissions within the limits established by legislation.

[7] Between 1995-98, 32 pollution control systems will have put in place, concentrating principally on air emissions (19 systems - 69% of the budget, with a 101.000kg/day reduction: particulate emissions have planned to fall from 103.6t/day (1995) to 1.71 t/day (1998)), water treatment (7 systems - 27%), and land (landfill and removal investment - 4%). The plans for 1997/98 include centralised particulates monitoring, the first step towards ISO 14000 which is pollution reduction and control, and improved training with the assistance of CETESB (environmental training was initiated in 1996).

[8] ISO 14000: The directives for the implementation of an Environmental Management System. ISO 14001**:** Specifications for the certification and/or evaluation of the Environmental System of an organisation. ISO 14010 to 14012**:** Establish the principles and procedures for Environmental Audits, and defining the criteria for

qualifying Environmental Auditors. The ISO 14000 Technical Committee identified the following basic principles: that environmental questions are being considered more important by consumers, governments and companies worldwide; the links between environmental conservation, business success and economic buoyancy are increasingly clear; the evolution of a global economy of goods and services determines the need for norms and harmonisation of environmental issues; the norms of environmental management must be formulated alongside quality management; the formulation of environmental management norms must be clearly communicated and permanently discussed with interested parties.

[9] Jose Maciel (1993, VII-1/7) cites the case of Acominas and the waste that is generated from the gas cleaning system in the steelmaking process. It is calculated that the waste is 59% iron and 2% coal and Acominas generates on average 7,000 t/m, which is a loss of 4141 t/m iron and 158t/m coal dumped in industrial waste deposits. Since the cost to deposit this material is approximately $5 per tonne of waste, acutal losses are US$35,000 per month. The iron can be recycled in the process and there is also research into commercialisation of the whole range of by-products that are unable to be recycled.

[10] In the case of USIMINAS, there are a range of activities designed to promote environmental consciousness in the company and with the community (Campos Soares, 1990): *Internal:* internal technical seminars; Environment Week, Tree Day, Operator Demonstrations, Green Areas Programme. *External:* plant visits; assistance to community initiatives (clubs and associations); and first grade environmental education assistance.

[11] As a response to the severe emissions in the locality, the company is part of the Winter Operation ‘Road Bath’ scheme (with CIESP, CETESB, DERSA and the traffic police) which is aimed at keeping roads damp in order to prevent resuspension of dust in the Vale do Mogi region (Cosipa, 1997).

[12] In the case of USIMINAS, investments in environmental technologies totalled US$ 81 million to 1976 but this figure would increase to US$ 170 million by 1989 - in one year alone (1981), US$ 68 million was invested. The balance between pollution media was as follows: 61.8% atmospheric; 37.4% water; 0.6% noise, and 0.2 soil. During the 1990s, the accumulated environmental investment has risen to US$ 356 million (1996) (Campos Soares, 1990; USIMINAS, 1996b).