Green manufacturing/Cleaner Production in Zimbabwe: Learning from Japanese Experiences

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By Charles Mbohwa.

Charles Mbohwa has a Bachelor Degree in Mechanical Engineering from the University of Zimbabwe and a Masters Degree in Operations Management and Manufacturing Systems from University of Nottingham, UK. He has taught at the University of Zimbabwe and has been a consultant/researcher for UNDP, DANIDA, DNV Zimbabwe and for the African Energy Policy Research Network (AFREPREN). He is currently a PhD student in Professor Fukuda's Laboratory at the Tokyo Metropolitan Institute of Technology in Japan. Contact Details: C/o Professor Dr. Shuichi Fukuda's Laboratory Department of Production and Information Systems Engineering, Tokyo Metropolitan Institute of Technology,6-6, Asahigaoka, Hino, Tokyo 191-0065, Japan. Tel.: +81-90-83166613 (Cell)Fax: +81-42-5835119 (Attn. Prof. Shuichi Fukuda) E-mail: cmbohwa@exmgfkta.tmit.ac.jp

Abstract

This paper discusses environmental issues in Africa and deals with the situation in Zimbabwe in more detail. Most people in Sub Saharan Africa live in the rural areas and make a living from agriculture and forest resources. In Zimbabwe, coal is the main source of energy in industry and in electricity production. Environmental management and green manufacturing (cleaner production) initiatives in the country have been limited. Three companies had been certified to ISO 14000 by June 1990. Green manufacturing assessments have been done in more than 80 companies. Cogeneration potential in steam using industry is high and a mini case studies of the sugar industries in Reunion, Mauritius and Zimbabwe`s electricity needs can be supplied by this sector. Ethanol is another viable by-product in the sugar industry. Pertinent legislation is necessary and Japanese examples are given. Lessons from NEC Corporation in the use of information technology are given as well as aspects that can be adapted from the experiences of Toyota Motor Corporation in a variety of areas.

1. Introduction

Cleaner Production (Green Manufacturing) is the **continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment.** The Cleaner Production activities promote strategies, policies and practices to prevent pollution from processes, products and services.[1] Historically the tendency has been to put in place end of pipe solutions involving treatment of pollutants, storage of hazardous substances created during processing in secure and safe places and cleaning up the soil, water and air when pollution levels are very high. **Green manufacturing emphasises pollution prevention through use of less or non-hazardous materials, waste reduction, recycling and process improvement.** The

environment is mainly made up of the **atmospheric air, water and soil.** Polluting it poses a danger to life and affects biodiversity. A strategy of pollution prevention at source offers a very viable way to protect the environment, hence the need for green manufacturing activities.

1.1 Summary of Sustainable Development Issues in Africa

In Sub-Saharan Africa, 70% of the poor people live in rural areas, and the rural population will continue to outnumber the urban population for nearly three decades to come. These people rely on wood for their energy requirements, resulting in deforestation. **Agriculture accounts for about 35% of the region's GNP, 40% of exports and 70% of employment.**[2] Millions of rural people are dependent on natural resources for food security and incomes. Agricultural production is associated with it heavy usage of polluting chemicals. An important challenge is the building of capacity in Africa for environmental management. In Malawi, Mozambique, South Africa and Zimbabwe, a project on integrated coastal zones management is in place now and stakeholders are being trained on the best ways of sustainable resource management. This will provide an opportunity to develop institutional structures, technical capability, and a philosophy of natural resource management that will eventually lead to environmentally and socially sustainable development. There is a need to focus on decentralization and ensure local communities were involved in natural resource management. However one of the main challenges is **growing environmental effects of manufacturing industries on coastal zones.** Studies on cleaner production in the sugar and meat processing industries have been done in more detail under a Danish International Development Agency (DANIDA)- Southern African Network for Training and Research on the Environment (SANTREN) supported project in order to partly address this concern.

There is need for a new environment strategy aimed at integrating environmental concerns into its mainstream poverty alleviation and economic development efforts. **African forests are believed to contain 45% of all global biodiversity** and thus a very special concern in Africa is the sustainable management of this rich resource. Forest-related activities and industries account for at least 10% of the GDP of 17 African nations. In Cameroon, Central African Republic, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon and Liberia, forest products account for more than 10% of trade. These industries need to put in place reforestation activities so that they can ensure sustainability. **There is a room to introduce greener cogeneration technologies in the wood industry making use of wood waste.** Electricity and heat should be standard by-products in the wood processing industry. The wood industry in Zimbabwe can produce more than 20 MW.

Africa produces only about 7% of the world's green house gases. Greater rainfall variability will result in more floods and more droughts, thus greater food insecurity and problems with diseases like malaria. Africa's partners will need to help it adapt to climate change by grasping opportunities offered by the **Global Environmental Facility (GEF), Joint Implementation (JI) initiatives, International Emissions Trading (IET) and the Clean Development Mechanism (CDM).** The new instruments from the Kyoto Protocol should be tested to develop renewable energy, to protect and expand forests, to help industries to implement green manufacturing technologies and to increase soil

fertility. It is clear that as the continent industrialises, it should adopt greener technologies and avoid the mistakes made by the industrialised countries. There is a need for efforts geared to helping countries not only build defences against extreme climate events like the droughts and flash-flooding, but also to finding innovative ways to harness renewable energy sources such as wind and solar power. For example the Energy and Water Sector Reform and Development Project in Cape Verde will increase efficiency by reducing barriers to the development of renewable energy sources and by promoting sound management of water resources.

1.2 Environmental Issues in Zimbabwe

The Zimbabwean economy can be divided into three major areas, namely Agriculture, industry and services. All of these have significant environmental impacts. The main industries are mining (coal, gold, copper, nickel, tin, clay, numerous metallic and non-metallic ores), steel, wood products, cement, chemicals, fertilizer, clothing and footwear, foodstuffs, beverages.[3] The services industry is mainly made up of financial services and the tourism sectors. Tourism has a serious effect on the environment. At its peak, about 2 million people visited Zimbabwe in one year, with the main attractions being the Victoria Falls, the national parks and the Great Zimbabwe Ruins. The number of visitors affects the ecological balance of these areas.

The major impacts on the environment are from agriculture, manufacturing, mining, energy usage and construction. River. **More than 70% of the country's electricity is produced from coal** and this releases carbon dioxide, sulphur oxides, nitrogen oxides and fine coal dust particles. The mining industry has caused a lot of land degradation, particularly small-scale gold panning. The usage of **cyanide and mercury by the miners** is not controlled and this has resulted in extensive water pollution. The manufacturing industries concentrated in urban areas are the best candidates for green manufacturing initiatives. Many of the companies have not exercised social responsibility, particularly in the capital city, Harare. This is a dangerous situation, given that **Lake Manyame, which supplies most of the city with water, is downstream of the drainage systems.** In the period between 1997 and 1999, **fish died in the lake.** One of the causes was Ammonia, directing implicating specific industries. The **city bylaws are so weak and not well applied** and no action was taken. However, environmental groups forced the companies to act and avoid release of pollutants into the wastewater streams. Most of them treat their effluent better now and they have introduced some form of environmental management systems.

A fertiliser company has been releasing a lot of sulphur and nitrogen oxides in a remote location where it operates. It has **caused acid rain and has affected the pastures** of farmers near it. For years the farmers up to 10 kilometres from the factory in the windward direction claimed compensation from the factory. It is now in the process of implementing cleaner production. There are **many petroleum and chemical processing industries in Zimbabwe**, which need to implement cleaner production. Generally all manufacturing companies in Zimbabwe need to implement environmental management systems. Green manufacturing should be used as a tool for assisting the companies to identify environmental aspects that they should pay attention to.

2 Environmental Management Systems and Cleaner Production Initiatives in Zimbabwe.

The International Standards Organisation (ISO) 14000 series certification in Zimbabwe has taken off slowly. **A survey conducted in April 2000, on 80 Zimbabwean companies showed that only 3 companies had established ISO 14001** certified environmental management systems. Ten companies had introduced environment management systems by that time. Out of these, 7 were doing so in accordance with ISO 14001 certification requirements and using ISO 14004 guidance standards.[4] The 3 ISO14001 certified companies were the only ones certified in the whole country.

There are a number of companies implementing a variety of activities like **waste management, pollution control, energy management, water management, cleaner production/green manufacturing, material/resource conservation** and environmental management in Zimbabwe. The United Nations Environmental Programme (UNEP) has developed a Cleaner Production Manual used by its Cleaner Production Centres all over the world. The **Cleaner Production Centre in Zimbabwe has assessed more than 50 companies** in Zimbabwe using the methodology. The Department of **Mechanical Engineering at the University of Zimbabwe has conducted more than 30 cleaner production assessments** in Zimbabwean companies. Some companies have taken action based on these assessments. However many of them have not been able to implement high cost measures due to current economic and financial difficulties that they face.

The Zimbabwean companies have operated under obsolete environmental laws, by-laws and regulations for a long time. **Most of the environmental laws were enacted between 1946 and 1982 and need urgent updating**. The city councils, town councils and rural district councils in Zimbabwe have ineffective legislation and enforcement capabilities. The discharge of effluent in urban areas is loosely controlled. Furthermore, laws enforcement should be made to be more effective. The notice procedures involve many memoranda and warnings, while the pollution continues unabated. Fines are rarely implemented and these are negligible, since most of them have not been updated since 1980. In real terms, **fines in the 1970s are about 100 times those in place now.**

Information technology applications in environmental management are still limited in Zimbabwe. The availability of e-mail and Internet facilities is low. Electronic documentation needs to be improved. Environmental management documentation can be mostly in electronic form. Document control, operating procedures and records can all be managed by using a database and a computer system. There is a need to improve the environmental educative capacity of information technology in Zimbabwe. There is room to explore **new methodologies and innovative applications of information technologies** to environmental monitoring, learning, awareness raising, training and decision-making. Internet technologies can be used to enhance and support education and information dissemination. This can help to improve environmental participation, environmental governance and related decision making.

3 Green Manufacturing in Zimbabwe, Reunion and Mauritius's Sugar Industries

In Zimbabwe, a unique opportunity presents exists to generate **clean energy using bagasse** in the sugar industry. Bagasse is the moist fibre that remains after sugar juice has been extracted from the shredded sugar cane. There are two companies that produce sugar in Zimbabwe. They are Triangle Limited and Hippo Valley Estates. They can be encouraged to invest in the **state of the art technology, which is already proven and in use in Mauritius and Reunion Islands** to invest in the power sector. Bagasse energy cogeneration in Mauritius has over the last few years demonstrated that the sugar industry has the potential to meet a substantial portion of a nation's energy needs. The current state of the art technology, in Mauritius, is the generation of firm power, using **a high-pressure boiler at 82 bars, with an efficient generation rated at over 120 kWh per tonne of cane.** Plants with a capacity of 70 MW have been put up in Reunion and Mauritius at a total cost of about US $110 million each. The companies can increase their profits whilst reducing Zimbabwe's foreign currency commitment to electricity imports substantially. In the case of Zimbabwe, the potential power capacity in the sugar industry has been estimated to be about 210 MW (**517 GWh of bagasse generated power for export to the grid**), using the Reunion example.

Table 1 A comparison of cogeneration technology indices

	Current Status in Zimbabwe	Best Available Technology Option from Mauritius	Estimated Cogeneration Potential for Zimbabwe if Best Available Technology in Mauritius is Applied	Best Available Technology Options Globally	Estimated Cogeneration Potential for Zimbabwe if Best Available Technology Globally is Applied.
Bagasse Gasification	None	None	Not Applicable	Not yet available potential 500 kWh/ Tonne Cane	2350 GWh
Highest Boiler Specifications	150 Tonnes steam per hour, 31 bars, 400° C	140 Tonnes Steam per hour, 82 bars, 525° C	705 GWh	140 Tonnes Steam per hour, 82 bars, 525° C	1175 GWh
Power Output per Tonne Cane	44 kWh/ Tonne Cane	150 kWh/ Tonne Cane	705 GWh	250 kWh/ Tonne Cane	1175 GWh
Power Export per Tonne Cane	0	110 kWh/ Tonne Cane	517 GWh	210 kWh/ Tonne Cane	1175 GWh
Maximum Turbo Alternator Capacity	20 MW	35MW	35 MW	35 MW	35MW
Bagasse Moisture Content	48%-50%	48%	705 GWh	48%	1175 GWh

The calculations of bagasse power exported are based on those achieved in Reunion Islands of 110 kWh per tonne of cane crushed. On the average Zimbabwe crushes 4.7 million tonnes of cane per year. Gasification is claimed to produce 500 kWh per tonne of cane. That would produce 2350 GWh. It is assumed that the sugar companies use 180 GWh and exports the rest. This is also based on two similar plants at Belle Vue in Mauritius. Each boiler needs 55 tonnes of bagasse per hour (185 tonnes of cane per hour)

to drive a 35 MW plant. A plant would need to operate at more than 560 tonnes of cane per hour in order to generate enough bagasse for a 105 MW plant.

If firm power plants are introduced at 82 bars, 525 degrees Celsius and 35 MW per boiler, the use of **293 750 tonnes of coal a year would be avoided. Emission of 885 000 tonnes of carbon dioxide and production of 47 000 tonnes of coal ash would be avoided**.[5] What is needed is to perform a financial and economic feasibility analysis so that the proposed projects can be considered for funding under the CDM, IET and JI mechanisms.

3.1 Ethanol in the Sugar Industry

Anhydrous ethanol is used to **blend petrol and a proportion of 26%** is used in Brazil. Such a policy has promoted the development of ethanol factories. Hydrated ethanol is used in **100% alcohol fuelled cars.** By 1999, a total of US$11.3 billion had been invested in the ethanol projects and this had saved the country US $28.7 billion dollars in foreign exchange. The **production and use of one litre of ethanol as fuel in place of gasoline avoids the net emission of 0.54 to 0.57 kg of carbon** as carbon dioxide. In Brazil, savings in the order of 46 mega tonnes of carbon dioxide equivalent are made, corresponding to about 20% of fossil fuel emissions in the country. This evaluation considers that the carbon in the ethanol is from sugarcane photosynthesis. **Blending of 3% ethanol with diesel** is being done in Rio Grande do Sul State in Brazil.

Triangle Limited in Zimbabwe produces ethanol. It can learn a lot from Brazilian experiences. The molasses is used as the main raw material for ethanol production. **Molasses is the substance remaining after sugar crystals have been removed from the mother liquid.** This ethanol production process takes care of the molasses produced as a waste or by-product during sugar processing. It is not allowed to dump it in the streams and water systems. It would otherwise pose a disposal problem. The stillage, which is the remains when alcohol has been distilled, produced as waste is used for irrigation and as a fertiliser. It contains, 15% Nitrogen, 1% Phosphorus and 2% Potassium. This is used for **irrigation and soil fertilisation, saving Z$50 million (US $ 2 million at 1999 prices) a year on fertiliser** at Triangle Limited. None of it gets into the drinking water. They select the right fields in order to avoid contamination of water. 400 million litres of stillage are produced a year. They are diluted to 1:100 and used for the irrigation of about 3 000 hectares. The output is about 120 000 litres of alcohol per day roughly 4 litres alcohol per tonne of molasses. The company used to produce absolute alcohol for petrol blending. **35 million litres of ethanol are produced** every year, bringing in revenue of about Z$360 million. Ethanol is currently mostly sold to the export market, which is more lucrative. After the severe droughts of 1992/93, blending of petrol with ethanol was stopped since the plant had to be closed. On resumption of production of ethanol, better markets were identified. These can purchase 90% ethanol content output and not 100% anymore as was required for petrol.

4 Japanese Experiences and Lessons

Japan has assumed leadership in a number of environmental technologies. Most of these are to do with replacement of hazardous materials, creation of less pollution technologies, material reuse, recycling of materials, waste pollution reduction and improvement of energy efficiency. The Pollutant Release and Transfer Register (PRTR) was enacted as a law in 1999. This law requires that **beginning in the financial year 2001, businesses must document and report the amounts of applicable substances released or transferred.** These will be sent to the government, which will then publish the collected results beginning in 2002. The Environmental Protection Agency in the United States does this already and Zimbabwe can work towards similar legislation. In Japan, the **Material Safety Data Sheets (MSDS) must be provided** during any transaction involving a substance that is subject to the PRTR law.

4.1 NEC Experiences[6] and Lessons for Zimbabwe/Africa.

NEC has a vision of an **Internet Society** (which it calls I-Society) of the 21st century. It envisages Internet usage by customers, companies, governments and communities. There will be services like net shopping and net auctions. There will be a possibility to share information and create distribution networks allowing people and products to circulate freely, efficiently and reducing waste and costs. It is envisaged that this will lead to carbon dioxide reduction, promote recycling, create disposal systems, which are appropriate for the waste and will enforce resource re-usage. A society will be created capable of reducing environmental impacts. IT business models like **online publication, online trading, e-commerce and Internet auctions** result in improved business efficiency and reduced costs. They reduce distribution load, warehouse and office space and the use of paper. These advantages have to be weighed against the increases in environmental impacts related to the increased usage of IT technologies like increased electrical power consumption. The frequency of individual transportation may increase due to better services being offered by electronic trading. Besides the convenience, prosperity and efficiency achieved, there is a need to consider also the impacts to the environment. NEC has a variety of software solutions in Japanese that resolves these issues. There is a need to create **English versions of such software and to test them in countries like Zimbabwe.** The environmental impacts due to the increase of IT equipment can be quantified. These are expressed in tones of carbon dioxide.

NEC has developed a Life Cycle Assessment (LCA) method, which can estimate the reduction in environmental impact when electronic commerce (e-commerce) is used. **LCA in this case is an assessment of a product's impact on the environment conducted by calculating energy consumption and carbon dioxide emissions over the course of the product's life cycle** from the extraction of raw materials through the manufacture, use and disposal of the product. Studies have been done using convenience stores as points of delivery. This assesses the contribution to the prevention of global warming through Internet shopping. Delivery of goods purchased anywhere through Internet, would be done at the Convenience stores. This new business model has been shown to **decrease carbon dioxide emissions by 40%**. This saving is through avoiding

transportation of shoppers to and from the various points of sale. Payments can be done by credit card or at the convenience store.

A model for determining the effect of **reusing car parts** was developed. Internet is the media used for selling the used car parts. In the year 2000, the company achieved business transactions for 30 000 parts. The model matches supply and demand for the used parts. The use of these parts results in saving the energy that would have been used to produce them. There are also savings related to the use of this model as compared to conventional ones. A **33% reduction in carbon dioxide** has been estimated for this model. Another business model involves efficient and paperless material procurement from the suppliers. NEC uses the **Internet to procure materials from the suppliers.** This business model was put in place in March 2000. Business transactions with 50 companies use this mode. This has replaced the use of telephones and faxes in making orders. The application of this business model, has resulted in **80% reduction in the energy consumed** by the telephones, fax machines and papers.

The company has also implemented the **world's first Environmental ISO 14001 audit** employing the electronic system called Net Audit. This uses the shared information system utilizing the Internet and intranet information management resources. The audits are being done more effectively since the ISO 14001 certification body is connected to the company through Internet. The system consists of three types of auditing. Net auditing enables the auditors to confirm the rules and regulations of the company's sites through the Internet. Then there is Net Interviews, which entails video-conferencing with top management. The third type is onsite auditing, which checks the actual operations and incorporates any questions that arise from the first two methods. The Japan Quality Assurance Organization (JQA), the largest certification body in Japan, has used the system. The ISO 14001 surveillance audit in 2000 made NEC the first company ever to be audited using an e-audit system. This technology can be used to reduce auditing costs in developing countries.

Net Audit has a number of advantages. About 60% of the auditing work, such as inspection of records, rules and regulations can be covered by the environmental information systems. NEC calls the system an "Eco Station". As a result, the actual onsite inspection system can be reduced to less than half when compared to conventional auditing systems. **On-site inspection becomes more focused and thorough.** The auditors are able to inspect the company's paper work at their own pace and at their own premises. The distributed management systems located at a number of different sites can now have their records being examined at the offices of the auditors. The auditors have the advantage of being able to obtain sufficient information in advance so that they can examine more efficiently the conditions on site. The auditors have been able to reduce the time for the inspection of management operations to 25% of the total original auditing time, time for interviews with top executives and managers has been maintained at the same level and the time for the inspection of documents and records has been reduced 5% of the original total auditing time. The **total time reduction was 60% and the approximate reduction in carbon dioxide emissions was 46%**

4.2 Toyota Experiences[7] and Lesson for Zimbabwe/Africa

Toyota Motor Corporation is certified to ISO 14001 and has made many useful innovations that the developing countries can benefit from. These are as follows:

- Car fuel efficiency for vehicles below 875 kg has gone up to 22.3 km per litre. **Hybrid cars have been able to achieve 29 km per litre**
- **Environmental accounting** is being used. Environmental costs in the year 2000/2001 were 95.2 billion yen or 1.2% of net sales
- Life Cycle Assessment has been successfully used. This is a quantitative assessment of the environmental impact of a product throughout its life cycle. The technique has been used for the **Estima hybrid vehicle.** The method **assesses the amount of carbon dioxide, non-methane hydrocarbons, particulate matter being granular material consisting mainly of fly ash and unburned hydrocarbon, nitrogen oxides and sulphur oxides emitted** during the products life cycle
- Setting targets and ensuring that **environmental performance is better than regulatory requirements.** Companies in developing countries can do the same
- Using environmental/green-purchasing guidelines. This has **encouraged the suppliers to get certified to ISO 14001** and to manage substances of environmental concern properly
- **Improving productivity and energy use** in order to reduce carbon dioxide emission. The levels of emissions should be quantified. A number of **companies can introduce high efficiency cogeneration systems** similar to the ones at some Toyota plants. **Excess power can be self-wheeled or sold to the utility**
- **Cleaner production or green manufacturing** strategies should be put in place in order to reduce waste volume substantially. Compared to 1990 levels, **Toyota reduced the amount of waste by 78% and achieved zero landfill waste in the year 2000**
- Company logistics can be improved through **optimal routing**, introduction of **reusable containers** and by using **less packaging and wrapping**
- **Recycling technologies** can be developed to ensure that waste is recycled. Companies can adopt efficient dismantling technologies, **reduce the usage of heavy metals** like lead and adopt the use of recyclable materials
- The new low pollution cars produced by the car industry can be used in cities in Africa. These are the **commuter electric vehicles and hybrid cars. Fuel cell cars** are being developed

- Other activities to learn from are the development of **energy saving houses** that use **renewable solar power**, **reforestation initiatives at corporate level** and the production of **animal feed and biodegradable plastics from sweet potatoes.**

5 Conclusion

Sustainable development has been defined as **providing the needs of today without compromising the needs of future generations.** It is about ensuring a **better quality of life for everyone now and forever.** This challenge extends to developing countries. Africa has to meet this challenge and a discussion of the Zimbabwean situation has shown some of the ways of having **sustainable development through cleaner production/green manufacturing** activities in the sugar industry. Countries like **Japan, USA and other industrialised countries** can support such initiatives by fully supporting such projects, which enable usage of renewable energy sources. The IET, JI and CDM facilities, which are part of the **Kyoto Protocol** can go a long way in meeting this requirement.

There are many more lessons that can be learned from the experiences of some Japanese companies. An example presented in this paper is the use of electronic environmental auditing and the development of specific environmental technologies. More work needs to be done in this direction so that **relevant environmental technology transfer can take place between Japan and developing countries** like Zimbabwe.

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[1] This is the United Nations Environmental Programme's definition of Cleaner Production. More details on Cleaner Production Green Manufacturing are on the following websites: More information on site: http://search.yahoo.com/search?p=Cleaner+Production ; Environmental Protection Agency (EPA) on http://search.yahoo.com/search?p=Environmental+Protection+Agency The green manufacturing focus is on http://google.yahoo.com/bin/query?p=Environmental+Protection+Agency+Green+Manufacturing&hc=0&hs=0 ; Japanese site http://google.yahoo.co.jp/bin/query?p=Cleaner+Production&hc=0&hs=0 The Japanese Green Manufacturing pages are on http://google.yahoo.co.jp/bin/query?p=Environmental+Protection+Agency+Green+Manufacturing&hc=0&hs=0

[2] More information on development and environmental issues in Africa can be obtained on http://www.geic.or.jp/z-thinkbase.html

[3] The details of the economic situation in Zimbabwe can be obtained on http://education.yahoo.com/reference/factbook/zi/econom.html

[4] This is according to a study by Madzinga A., Implementation of ISO 14000 Environmental Management System at BICC CAFCA- A Lesson to Zimbabwean Industry. Project Report June 2000, Department of Mechanical Engineering, University of Zimbabwe.

[5] Avoided tonnages of coal are based on the calorific value of coal and bagasse. The coal required producing the same amount of electricity that the 1,4 million tones of bagasse can produce annually in Zimbabwe is computed. Carbon dioxide and coal ash estimates are simply computed from the amount of equivalent coal.

[6] The details are in " A look at the Next chapter of Ecology and Technology, NEC Annual Environmental Report 2001, April 2000 to March 2001. Further details are on http://www.nec.co.jp/english/kan

[7] This summarizes the most important and relevant environmental developments at Toyota Motor Corporation given in the company's Environmental Report 2001. More information can also be obtained on http://www.global.toyota.com/