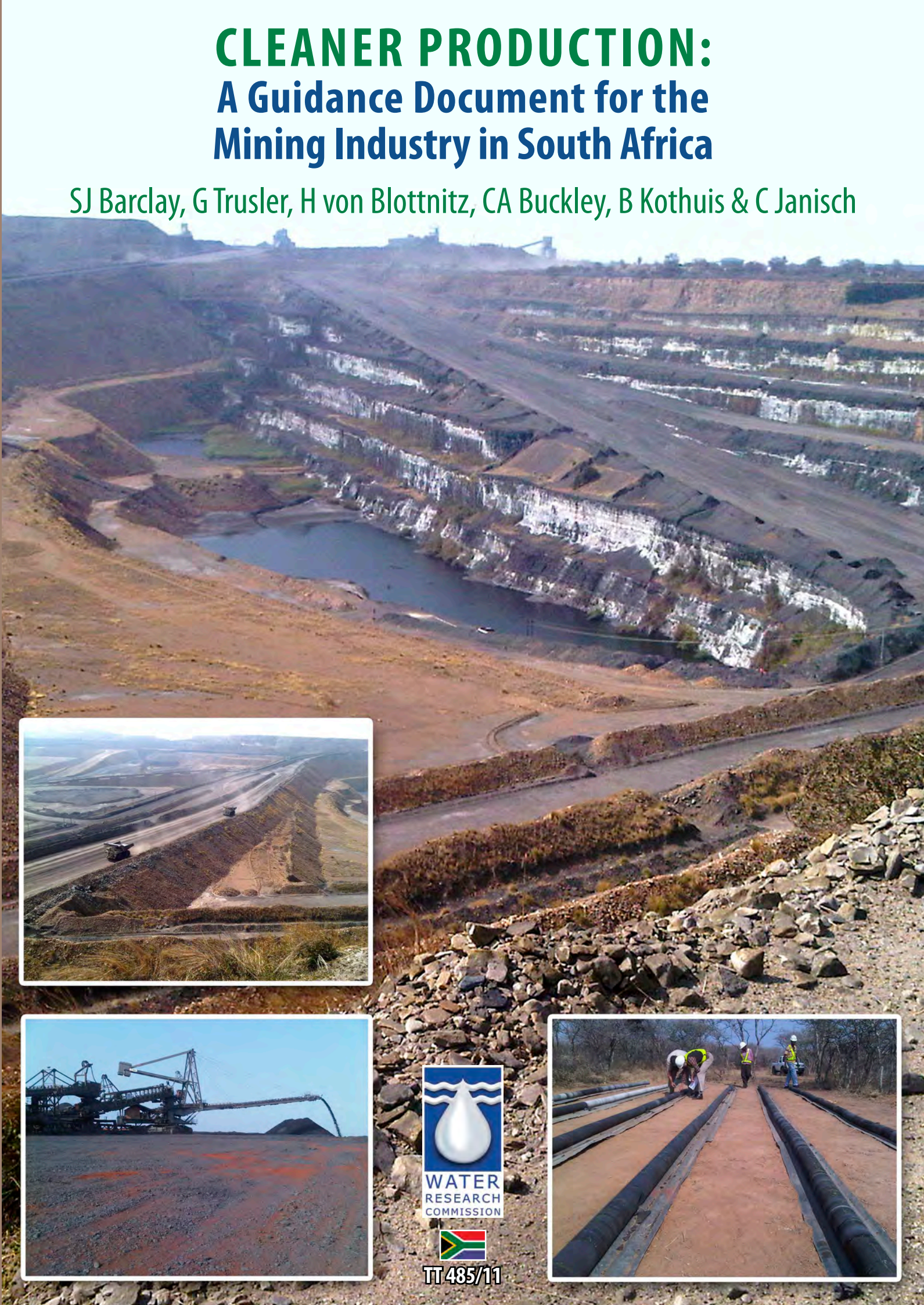
CLEANER PRODUCTION:
A Guidance Document for the Mining Industry in South Africa

SJ Barclay, G Trusler, H von Blottnitz, CA Buckley, B Kothuis & C Janisch



WATER RESEARCH COMMISSION

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Cleaner Production:

A Guidance Document for the Mining Industry in South Africa

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Report to the
Water Research Commission

by

Digby Wells and Associates

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BACKGROUND

This Cleaner Production Guidance Document has been prepared under a Water Research Commission (WRC) Project investigating the introduction of cleaner production technologies to the South African mining sector. This project was conducted from 2004 to 2008, and investigated the use of cleaner production tools such as quick scan assessments, life cycle assessments, and cleaner production forums to encourage and motivate the mining industry to implement cleaner production in order to reduce their environmental impact and increase profitability.

The project consortium, lead by Digby Wells and Associates, consists of BECO-Institute for Sustainable Business, the University of KwaZulu-Natal, University of Cape Town, Claire Janisch, Susan Barclay CC and Andrew Barker.

AIM AND SCOPE

The aim of the Guidance Document is to assist the mining industry and its regulators, in determining the benefits of implementing cleaner production and the methodology involved. Case studies and examples are incorporated to demonstrate how cleaner production has been implemented successfully in mining companies, both locally and internationally, and checklists are used to guide the user through each stage of the cleaner production process. A brief review of relevant legislation is included and a comprehensive list of recommended readings and web addresses is provided.

The Guidance Document focuses on the main minerals being mined in South Africa, namely coal, gold and platinum, but the methodology described is applicable to all minerals and mines.

DEVELOPMENT PROCESS

The Guidance document was prepared with the input from each member of the project consortium and a draft document presented at two workshops in September 2007 to obtain input from industry, government and other stakeholders. Over 100 participants attended these workshops and included the following organizations:

- Chamber of Mines
- Department of Water Affairs and Forestry
- Department of Environment Affairs
- Department of Minerals and Energy
- Anglo Platinum
- Impala Platinum
- University of Johannesburg
- Mpumalanga Department of Agriculture and Land Administration.
- GDACE
- DeBeers Consolidated Mines
- BHP Billiton
- Anglo Gold Ashanti
- Mintek
- Driefontein Consolidated
- Optimum Colliery
- Sasol Mining
- Kloof Gold Mine
- Hatch
- DRDGOLDSA
- Landau Colliery
- WITS
- Rand Water

Details on these workshops are provided in the ***Awareness Campaign Report*** of the project documentation.

Further input was obtained from the project steering committee members. All feedback was recorded and recommendations / suggestions were incorporated into this final Guidance Document.

TARGET AUDIENCE

The Guidance document is aimed primarily at those working in and with the mining industry, with a secondary focus on those government departments regulating the mines. The document will assist mining companies in implementing a cleaner production programme, while at the same time, providing the regulators with suggestions on how to promote and encourage the process. It will also assist companies and regulators in identifying where they stand with respect to best practice, where opportunities exist for

implementing cleaner production options, and where cleaner production technologies have already been implemented. Consultants to the industry will also benefit from the Guidance Document as it will provide necessary background information to the sector and suitable cleaner production opportunities.

STRUCTURE

The Guidance Document is divided into 6 Chapters and 7 Appendices as shown below:

Chapter 1: Introduction to the mining industry in South Africa, together with an overview of the associated environmental impacts.

Chapter 2: A review of relevant legislation with a focus on laws and regulations that promote cleaner production, and also where cleaner production will assist companies in complying with legislative requirements.

Chapter 3: An introduction to cleaner production, its benefits, the methodology of implementing a cleaner production programme, and how to identify and overcome barriers.

Chapter 4: An introduction to some cleaner production tools, including monitoring and targeting, life cycle assessment, cleaner production forums and raising awareness.

Chapter 5: Guidance as to how to incorporate cleaner production into existing environmental activities within the mining industry, with an emphasis on environmental management systems and international best practice.

Chapter 6: Aimed primarily at the regulators to provide guidance on how to identify when cleaner production is being implemented and to further promote cleaner production practices.

Appendix 1 Checklists/worksheets for each stage of the cleaner production process (for use with Chapters 3, 4 and 5)

Appendix 2 Checklists aimed at each roleplayer in the mining industry.

Appendix 3 Cleaner production opportunity checklists.

Appendix 4 Cleaner production reporting format (UNIDO).

Appendix 5 Mining by-products and wastes.

Appendix 6 References, recommended readings and sources of further information.

Appendix 7 Useful contacts.

Case studies are included throughout the Guidance Document to illustrate the steps to implementing cleaner production and the related benefits. Summary points are provided at the end of each Chapter and relevant recommended readings listed.

Checklists / worksheets are provided in the Appendices to give you step-by-step guidance in working through each stage of implementing a Cleaner Production Programme.

HOW TO USE THE GUIDANCE DOCUMENT

This Guidance Document is intended to assist mining companies, regulators to the mines and consultants in how to implement a programme of cleaner production, how to identify cleaner production opportunities, and how to sustain such a programme through promotion and awareness raising.

In order to achieve this, the following process is recommended:

- Understand the main *mining processes* in South Africa and the associated *environmental and health impacts*
- Ensure you have a good understanding of the *concept of cleaner production*
- Familiarise yourself with the *legal and policy framework* relevant to the implementation of cleaner production in the mining sector
- Familiarise yourself with the *main steps* involved in implementing a structured cleaner production programme within an organisation
- Make use of the *checklists/worksheets* provided to enable you as a mining company to implement each stage of a cleaner production programme, and as a regulator, to identify where opportunities for cleaner production exist, or have been undertaken
- Make use of the *tools of cleaner production* such as monitoring and targeting, identifying the true cost of waste generated and life cycle thinking
- Identify the possible *barriers* to implementing cleaner production and ways in which these can be overcome
- Understand how cleaner production can be *incorporated* into existing environmental management programmes
- Investigate the possibility of joining or creating a *cleaner production forum* to allow for the exchange of information and advice on cleaner production activities
- Identify suitable cleaner production practices for various mining operations based on best practice by making use of the *checklists* provided
- Be aware of the importance of *raising awareness* at all levels of staff in cleaner production practices
- *Understand your role* as a mining company, regulator or consultant in implementing and promoting cleaner production
- Make use of the extensive list of *references*, internet resources and case studies available.

Various Symbols are used throughout the Guidance Document to indicate where a particular point is being emphasised. These are:

A hint, tip or good idea

An interesting fact or information

A tip for regulators

A case study

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"Introduction of Cleaner Production Technologies in the South African Mining Industry"

The Reference Group Committee responsible for this project consisted of the following persons:

Mr HM du Plessis	Water Research Commission (Chairman)
Ms M Mohr-Swart	Chamber of Mines
Mr LL LaBuschagne	Department of Minerals and Energy
Mr D Salmon	Anglo American Corporation
Mr N Raphulu	National Cleaner Production Centre
Mr S Mokoena	Department of Environmental Affairs
Dr D Rogers	CSIR, M & Mtek

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We are grateful to each individual with whom we held discussions during the research period. We are particular grateful to those mining groups and collieries that have supplied us with information and those individuals who gave of their time to attend the workshops and provide feedback on the Guidance Document. Their valuable contribution made this project possible.

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List of Abbreviations

BPG	Best Practice Guideline
CP	Cleaner Production
CPF	Cleaner Production Forum
DEAT	Department of Environment Affairs and Tourism
DME	Department of Minerals and Energy
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ICMM	International Council for Mining and Minerals
MRD	Mine Residue Deposits
NCPC	National Cleaner Production Centre
NEMA	National Environment Management Act
NWA	National Water Act
PCD	Pollution Control Dams
PGM	Platinum Group Metal
UNEP	United Nations Environment Programme
UNIDO	United Nations International Development Organisation
WM	Waste Minimisation
WMC	Waste Minimisation club
WRC	Water Research Commission

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Chapter 1: Mining in South Africa

This chapter provides an overview of the main mining operations in South Africa and the related environmental impacts. More detailed information on the history of mining in South Africa can be found in the ***Water Related Threats*** document prepared under this project.

1.1 MINING OPERATIONS IN SOUTH AFRICA

South Africa is a leading world supplier of a range of minerals and mineral products of consistently high quality. Mineral commodities were exported to 101 countries during 2005. *(www.dme.gov.za).*

In 2005 (Chamber of Mines, 2005), the mining industry accounted for 6.2% of gross domestic product (GDP) versus 6.3% in 2004. It also contributed R105-billion to South African exports, representing 30% of the country's total merchandise exports, and directly employed an average of 442 911 workers.

Since the focus of the Guidance document is on diamond, coal, gold and PGM mining, a summary of the performance of each of these operations is provided in Table 1.1.

Did you know?

- ***In 2005, about 55 different minerals were produced from 1 113 mines and quarries***
- ***45 produced gold***
- ***26 produced platinum-group minerals***
- ***64 produced coal***
- ***202 produced diamonds***

All as primary commodities, with an increase of 120 mines from 2004.

Source: www.dme.gov.za

Table 1.1 Overview of performance for the Gold, Coal, Diamond and PGM in South Africa (*Chamber of Mines, 2005*)

	Diamonds	Coal	Gold	PGM
Share of global market (%)	13%	10% hard coal	11.8%	48.1%
Position in global market as supplier	Third largest	Sixth largest	Largest	Largest
Local production (2005)	15.8 million carats R 10.2 billion	R 36 billion	297.3 tons	303 tons
Direct contribution to GDP	0.4%	1.2%	1.4%	Not provided
Contribution to exports	2.8%	6.1%	7.8%	Not provided
Number of employees	21 976	56 971	160 000	155 030

A brief overview of each of these main mining operations is provided below.

Some information on the mining of uranium for nuclear energy has also been included in this section.

1.1.1 Diamond mining

Did you know?

Only 15 to 20% of the world's diamond production is gem quality; the rest is destined for industrial use.

Source: www.bullion.org.za

In South Africa, volcanic Kimberlite pipes are mined as both underground and openpit operations. A variety of mining methods are employed ranging from blasting and then hauling the ore away by huge trucks in open-pit mines, to open-benching, block-caving, open-sloping and panel-retreat operations underground.

Natural-diamond 'industrials' – 'boart' – (along with synthetic diamonds) are required for their hardness in cutting; sawing; wire-drawing; drilling

purposes, mainly in the masonry, mining and oil businesses; and for grinding and polishing in the engineering industry (*www.bullion.org.za*).

1.1.2 Coal mining

South Africa's indigenous energy resource base is dominated by coal. Internationally, coal is the most widely used primary fuel, accounting for about 36% of the total fuel consumption for the world's electricity production. About 77% of South Africa's primary energy needs are provided by coal. In addition to the extensive use of coal in the domestic economy, about 28% of South Africa's production is exported, mainly through the Richards Bay Coal Terminal, making South Africa the fourth-largest coal exporting country in the world.

Production is concentrated in large mines, with 11 mines accounting for 70% of the output. South African coal for local electricity production is among the cheapest in the world. The beneficiation of coal, particularly for export, results in more than 65 Mt of coal discards being produced every year.

Mining of coal is carried out either as opencast mining, or underground mining.

- Opencast mining: This accounts for around 49% of operations, and can have coal recovery rates approaching 90%.

In underground mining, 3 different techniques are used:

- "Bord and Pillar" method: This is the most common technique, accounting for just under half of the total production.
- Rib-pillar extraction
- Long wall mining

Coal Facts

Coal is used in the following local industries:

- ***62% is used for electricity generation;***
- ***23% for petrochemical industries (Sasol);***
- ***8% for general industry;***
- ***4% for the metallurgical industry (Mittal); and***
- ***4% is purchased by merchants and sold locally or exported.***

Source: www.dme.gov.za

About 21% of the run-of-mine coal produced is exported, and 21% is used locally (excluding power-station coal). The rest is not saleable and is discarded. The need to beneficiate coal for export and other high level uses requires a process plant. These generally produce two types of waste: coarse discard and fine slurry.

1.1.3 Gold mining

The development of the technical capacity to mine deep-level ore bodies has seen South Africa become a world leader in deep-level mining technology. This type of gold mining is very capital intensive and required special financial instruments to ensure funding for these long life operations. This is because of the massive capital required for ventilation, cooling, hoisting, underground tunneling and surface processing plants, and the need to have the mines operated by large numbers of workers, particularly with respect to hard rock mining. In the case of gold mining the depth of operations has increased to levels of 4 km below the surface in some cases.

Open pit gold mines are not commonly found in South Africa. Gold mine wastes are generally deposited on large surface slimes dams by pumping the fine gold slurry out to these facilities. Cyanide is used to dissolve the gold which is absorbed onto carbon particles and lime is added to reduce cyanide consumption.

1.1.4 Platinum Group Metal (PGM) mining

The mining of platinum ores is similar to gold mining inasmuch as the ore body is a thin, tabular reef covering an extensive area. This enables a progressive method of mining – the reef is drilled and blasted to advance the face, support being installed for local control of the hanging wall.

PGM recovery processes can be grouped into the four stages of concentration, smelting, base metals removal, and precious metals refining.

- Concentration: The ore is ground to liberate mineral particles. These are then recovered in the form of a concentrate by froth flotation. The ore mineralogy dictates both the fineness of grind required for liberation and the ideal flotation conditions. The fine waste is deposited hydraulically on large slimes dams.
- Smelting: The concentrate is melted in an electric furnace. On melting, the concentrate separates into two layers. The upper layer is a silicate/oxide slag which is tapped off and then either discarded or returned to concentration. The lower layer is a sulphide matte which is sent for converting. Excess sulphur and iron are oxidised in a refractory lined vessel. Fluxing agents are added to form an iron-rich slag that is skimmed off and returned to the furnaces. The converter matte is then sent for base-metal removal.

PGM Facts

PGM's are used in a wide range of industrial applications such as:

- ***Autocatalysts***
- ***Jewelry***
- ***Investment***
- ***Industry***
  - ***electrical and electronics***
  - ***chemicals***
  - ***petro-chemical***
  - ***glass industry***
  - ***motor manufacturing***
  - ***Medicine***
  - ***Fuel Cells***

Source: www.bullion.org.za

- Base metals (copper and nickel) are removed from the converter matte either by leaching or by a combination of magnetic separation and leaching processes. Problem elements such as selenium, arsenic and tellurium are also removed. The base metal refinery concentrate is sent for further processing into refined precious metals.
- Refining: Improved separation and refining procedures have become available for all of the precious metals. These commonly involve operations such as solvent extraction or ion exchange.

1.1.5 Uranium Mining

Uranium mining is the process of extraction of uranium ore from the ground. As uranium ore is mostly present at relatively low concentrations, most uranium mining is very volume-intensive, and thus tends to be undertaken as open-pit mining. It is also undertaken in only a small number of countries of the world, as the resource is relatively rarely found. A prominent use of uranium from mining is as fuel for nuclear power plants.

Did you know?

- ***South Africa has two nuclear reactors generating 6% of its electricity.***
- ***Its first commercial nuclear power reactor began operating in 1984.***
- ***Government commitment to the future of nuclear energy is strong.***
- ***Budget funding for the construction of a demonstration Pebble Bed Modular Reactor was given in 2004.***

Source: http://www.uic.com.au/nip88.htm

Uranium production in South Africa has generally been a by-product of gold or copper mining. In 1951 a company was formed to exploit the uranium-rich slurries from gold mining and in 1967 this function was taken over by Nuclear Fuels Corporation of South Africa (Nufcor), which in 1998 became a subsidiary of AngloGold Ltd. It produces over 1000 tonnes U_3O_8 per year from uranium slurries trucked in from various gold mines and Palabora copper mine (*Uranium Information Centre, Briefing paper no 88, 2007).*

There is a number of new uranium projects planned for South Africa due to the recent substantial increase in the uranium price. Most of this will be produced from gold ores and will be combined with gold extraction.

1.2 ENVIRONMENTAL IMPACT OF MINING

Protection of the environment requires careful planning and commitment from all levels and groups within a mining company. Mining, and associated processing, have the potential to cause a number of environmental problems if projects are not properly planned and managed.

Potential problems include (*Water Related Threats project document, 2009 and Environment Australia, 2000*)*:*

- Partial or total dewatering of aquifers.
- Wind and water erosion (erosion may increase sediment loads and decrease water quality in streams, reduce the productivity of the soil and create a dust nuisance);
- Contamination of surface or ground water by sediment, mobilisation of salt, release of toxic elements from overburden, tailings or wastes, or spills of oil, chemicals or fuel as surface runoff or as underground seepage;
- Changes to surface and ground water flows and levels;
- Damage to soils including salination, acidification, pollution and compaction or loss of soil structure;
- Dust or noise nuisance, vibration and a reduction of visual landscape values;
- Generation of tailings and other wastes that may release toxic elements or be mobilised by erosive forces;
- Gaseous emissions from mineral processing, methane emissions from mine openings, fumes from coal seam fires;
- Possible sudden failure of engineered containment structures such as tailings dam embankments, settling and holding ponds, resulting in release of high concentration/high volume contaminants;
- Acid mine drainage (tailings, ore and waste dumps, and old mining areas which contain sulphur or sulphides such as iron sulphide, can generate acid through bacterial oxidation when exposed to moisture and oxygen – this acid leachate may then mobilise heavy metals that can be released into the environment;
- Loss of flora including direct losses through clearing and indirect effects due to the spread of plant pathogens and weeds;
- Loss of fauna including direct losses through vegetation clearing and the indirect effects on species through the reduction and fragmentation of habitat and the introduction of feral animals;
- Damage to heritage sites;
- Destruction of adjacent habitats arising from the development of camps, towns and services stimulated by the mining project; and
- Possible exposure to radiation from the mining of uranium. Although uranium itself is not very radioactive, it is associated with more radioactive elements such as radium and radon in the ore.

All these issues result in an impact on health, water and air quality; cause noise and soil erosion and subsidence; and have an impact from transportation. In addition, general waste is generated that has to be disposed of.

Table 1.2 provides an overview of these impacts together with the main source of generation.

Table 1.2 Overview of environmental and health impacts related to mining

(*summarised from Environment Australia (1995(a)*)

Aspect	Form of pollutant	Source	Impact
Air quality	Dust particles Methane Fumes	Blasting Transport Open-cut mining Mineral processing Mine opening	Health of employees Aesthetic Greenhouse gas impact
Noise	Noise and vibration	Excavation Transport Ventilation fans Blasting	Health
Water quality	Sediments Suspended solids Conductivity (saline) pH Oil Dissolved heavy metals Cyanide Other chemicals	Run-off Process plants Workshops Washing of vehicles Acid mine drainage Leachate Sewerage Containment structure failure	Ground water contamination Aquatic life River water quality
Soil		Excavation	Subsidence and erosion Loss of fauna and flora
Transport	Dust Oil Fuel Noise	Washing Driving	Congestion Groundwater/river pollution
Waste	Slime Mud Tailings Spent reagents Oils and lubricants General refuse	Processing plants Staff	Landfill space Water quality Health

These impacts can be minimized through following best practice, or cleaner production, procedures and through good environmental planning. With respect to the protection of water resources introduction and use of Cleaner Production principles in the South African mining industry are essential to:

- Reduce water consumption and improve efficiency for each unit of product produced to ensure water availability for current and future projects;
- Reduce long term water management and treatment costs;
- Reduce chances of spills and runoff contaminating surface water resources; and
- Comply with water, waste, environmental and mining legislation.

A detailed checklist of suitable options to eliminate or reduce these environmental impacts is provided in ***Appendix 3***.

Case Study 1: Australian Coal mine benefits from reducing noise

Terrible colliery is an underground coal mine 20 km south-west of Newcastle in New South Wales. The colliery is owned by Oceanic Coal Australia Limited and four other partners.
The mine is located within a residential suburb of Terrible. It is surrounded by residences as well as three nursing homes (one of which borders the southern boundary). The mine received noise complaints and these were tracked to two sources, the mine ventilation fans and the compressed air plant.

The following interventions were implemented to reduce noise. These included:

- ***Ventilation fan blades were balanced using laser technology***
- ***Fan blades were sandblasted then coated with an epoxy coating to reduce noise vibration.***
- ***A preventative maintenance management plan was implemented to ensure regular cleaning of the noise attenuators and a purpose-built vacuum cleaner purchased.***
- ***The whole fan installation was enclosed in a building on three sides. The structure was lined with noise-suppressing material.***
- ***A muffler was designed and fitted to a noisy radiator unit.***
- ***Compressor enclosures were fitted with noise-suppressing material to reduce noise at the source.***
- ***Regular inspections of doorways to the compressor room were introduced, to ensure that they were kept closed after dark.***

Besides eliminating all complaints, the mine benefited from reduced power consumption, lower maintenance costs and improved ventilation efficiency.

Source: Environment Australia (2000): Extract from Case Study 2

CHAPTER 1: SUMMARY

√ Obtain an understanding of the environmental impact associated with your operation

√ Use the following chapters to identify how to identify the source of the environmental impacts

√ Use the checklists in Appendix 3 to identify suitable cleaner production options

RECOMMENDED READINGS

Chamber of Mines web site: *www.bullion.org.za*

Department of Minerals and Energy (DME) web site: *www.dme.gov.za*

Thesis by Reddick J (2006)

Environment Australia (1995, 1997, 1998(a), 1998(b), 1998(c), 2000)

Uranium Information Centre web site: *www.uic.com.au*

Water Related Threats Document (WRC Report No 1553/1/11)

DWAF Best Practice Guideline Documents (2006, 2007 and 2008)

There are number of bills, acts and regulations which govern the environmental impact of industrial processes. The mining industry is regulated by National Government through their provincial, offices. On a National level there are acts such as the Water Act (NWA), the National Environmental Management Act (NEMA), and the Occupational Health and Safety Act (OSH Act). On a Provincial level, policies are often passed that outline environmental protection procedures specific to that province. Regulations that are most likely to affect a mining company are those that are passed on a National level and regulated through the Department of Minerals and Energy (DME), the Department of Water Affairs and Forestry (DWAF), and the Department of Environment and Tourism (DEAT).

This chapter will highlight some of the current legislation, policies and strategies that are relevant to the mining sector. It is not meant as an exhaustive review or list, but to highlight where cleaner production is promoted, or where the implementation of cleaner production will assist with compliance. These include both local requirements, as well as international agreements.

Cleaner production is promoted by the authorities as each mine has to apply for a water use license for its various uses in terms of section 21 of the NWA. The authorities use the best practice guidelines when assessing these applications to ensure that the mine operators adhere to the required standards. You are thus encouraged to make use of, and familiarize yourself with, these guidelines.

Table 2.1 lists relevant government departments, while **Table 2.2** provides a summary of the main acts, regulations, strategies and guideline documents that are applicable to the mining sector. The main aspects of each regulation relating to cleaner production are provided, together with reference to where further information can be obtained.

More detailed information on the NEMA and the DWAF Best Practice Guideline Documents are also provided in this chapter.

Table 2.1: List of national government departments

Department	Web address
South African Government	www.gov.za
Department of Environment Affairs and Tourism	www.environment.gov.za
Department of Water Affairs and Forestry	www.dwaf.gov.za
Department of Trade and Industry	www.dti.gov.za
Department of Minerals and Energy	www.dme.gov.za
Department of Labour	www.labour.gov.za

Table 2.2: List of legislation relevant to the mining sector and cleaner production

Legislation	Main relevant points	Relevance to cleaner production
Act / Bill		
South African Constitution (No. 108 of 1996) www.gov.za	• States that every person has the right to a clean and healthy environment. • States that the environment is to be protected for the benefit of present and future generations	• The implementation of Cleaner Production by industry reduces environmental impact and leads towards sustainable development
The National Water Act (No. 36 of 1998) www.dwaf.gov.za	• Emphasises the effective management of South Africa's water resources through the basic principles of Integrated Water Resources Management • Seeks to achieve social equity, economic efficiency and ecosystem sustainability • Obliges any user of water to avoid/minimize pollution of water resources • Stipulates that water use authorizations must be obtained for all water uses • Provision for penalties	• Cleaner production promotes source reduction thereby reducing volume of water used, and volume and toxicity of effluent discharged

Table 2.2 Continued

Legislation	Main relevant points	Relevance to cleaner production
Act / Bill		
The Minerals and Petroleum Resources Development Act ((MPRDA – Act 28 of 2002) www.dme.gov.za	• Legislates the official policy concerning the exploitation of the country's minerals. • Addresses environmental sustainability of the mining industry • Can apply penalties for non-compliance. • Requires that an environmental impact assessment be undertaken for mining operations.	• Cleaner production is recognized as a tool leading to sustainable development
The National Environmental Management Act (No. 107 of 1998) www.environment.gov.za	• Provides the guiding legislation and framework for environmental management in South Africa • Obliges anyone who pollutes or degrades the environment to take reasonable measures to stop doing it • If pollution cannot be reasonably avoided, to minimise and put right the damage	• Cleaner Production is aimed at reducing waste/pollution *at source* • *See Section 2.1*
The Draft Energy Bill www.dme.gov.za	• Gives DME the mandate to establish an energy efficiency programme.	• Cleaner production includes reducing the use of energy in processing

National Environment Management: Waste Management Act (2009)
www.environment.gov.za
	• Aims at protecting health, well being and the environment
	• Encourages minimisation of consumption of natural resource
	  • Avoidance and minimisation of the generation of waste
	  • Reuse/recycling and recovery of waste
	  • Treatment and disposal as a last resort
	  • Aims to set standards on a national, provincial and local level for waste generation
		• Cleaner production encompasses all of these aspects
		• Cleaner production will assist in meeting any standards that may be set in the future

National Environment Management: Air Quality (Act 39 of 2004) www.environment.gov.za	• Provides for national norms and standards to regulate air quality monitoring • Penalties can be enforced if any contravention of the air emission standards takes place.	• The use of cleaner technologies and cleaner production practices are promoted as key factors in improving air quality
Water Use Regulations (Government Notice No. 704)	• Provides regulations on the use of water for mining and related activities aimed at the protection of water resources	• Cleaner Production promotes sustainable water management
Strategy:		
National Energy Efficiency Strategy (2005) www.dme.gov.za	• Sets a national target for energy efficiency improvement of 12% by 2015 • For industry and mining there is A Target Final Energy Demand Reduction of 15% by 2015	• Target is expected to be achieved by implementing various energy efficiency programmes
National Waste Management Strategy www.environment.gov.za	• presents a long-term plan (up to the year 2010) for addressing key issues, needs and problems experienced with waste management in South Africa • Follows the waste management hierarchy	• Cleaner production is at the top of the waste management hierarchy

Table 2.2 continued

Legislation	Main relevant points	Relevance to cleaner production
Strategy		
National Cleaner Production and Sustainable Consumption Strategy www.environment.gov.za	• Promotes resource efficiency • Supports the development of more competitive and environmentally friendly industries • Provides practical economic and technical tools to local government and industry	• Cleaner production provides the technical and economic tools to achieve sustainable development
Water Conservation and Water Demand Strategy for the Industry, Mining and Power Generation Sectors (2004)	• Promotes efficient use of water • Encourages demand side management of water	• Cleaner production promotes a reduction in water use, and water reuse and recycling
Guideline Documents		
Environmental Management Plan for prospecting rights or mining permit (May 2004)	• Aims to provide a national standard for the submission of Environmental Management Plans • Aims to ensure compliance with Regulation 52 of the MPRDA. • Assists regional offices of the DME to obtain enough information about a proposed prospecting/ reconnaissance or mining permit operation to assess the possible environmental impacts from that operation and to determine corrective action • Contains a simple environmental impact assessment and relevant forms	• A cleaner production programme fits into an environmental management plan as it identifies sources and quantities of waste, and options for reducing this at source. • All types of waste are included in a cleaner production programme –this includes minimising the consumption of resources (water, energy) raw materials and chemicals, thereby reducing the quantity and toxicity of any discharges to land, air and water
Best Practice Guidelines for Water Resource Protection in the South African Mining Industry (DWAF, Series A, G and H)	• A series of guides detailing best practice relating to water management and protection for various mining operations. • Checklists for best practice are provided • *See Section 2.2*	• Pollution prevention at source and the application of cleaner production techniques is promoted in all the guideline documents.

2.1 NATIONAL ENVIRONMENTAL MANAGEMENT ACT (NEMA)

Section 2 of the National Environmental Management Act (NEMA) comprises a number of national environmental management principles, including the following which are of direct relevance to waste management and cleaner production:

- Avoid or, where it's not possible to altogether avoid, minimise and remedy pollution and degradation of the environment [Section 2(4)(a)(ii)].
- Avoid waste, or where it cannot be avoided, minimise and re-use or recycle where possible, and otherwise dispose of it in a responsible manner [Section 2(4)(a)(iv)].
- Use non-renewable resources in a responsible and equitable way, taking into account the depletion of the resource [Section 2(4)(a)(v)].
- Use renewable resources in such a way that it does not exceed the level beyond which their integrity is jeopardised [Section 2(4)(a)(vi)].
- The "precautionary principle", whereby a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions [Section 2(4)(a)(vii)].

- Responsibility for the environmental, health and safety consequences of a policy, programme, project, product, process, service or activity exists throughout its life cycle [Section 2(4)(e)].
- The "polluter pays" principle, whereby the costs of remedying pollution, environmental degradation, consequent health effects….must be paid for by those responsible for harming the environment [Section 2(4)(p)].

Section 24(7) of NEMA stipulates the minimum procedures for investigating, assessing and communicating potential impacts of activities where they may have a significant impact on the environment, and where such activities have to be authorised in terms of existing legislation. These minimum requirements include:

- Investigation of potential impact, including cumulative effects, of the activity on the environment [S24(7)(b)].
- Investigation of mitigation measures to keep adverse impacts to a minimum [S24(7)(c)].

Section 28(1) of NEMA states that every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or to minimise and rectify such pollution or degradation.

2.2 DWAF BEST PRACTICE GUIDELINE DOCUMENTS

The Best Practice Guidelines for Water Resource Protection in the South African Mining Industry were prepared for all mines and regulators to the mining sector. The aim of these Guidelines documents is to *(DWAF, 2006):*

- Be utilised by the mining sector as input for compiling water use license applications (and other legally required documents such as EMPs, EIAs, closure plans, etc.) and for drafting license conditions.
- Serve as a uniform basis for negotiations through the licensing process prescribed by the National Water Act.
- Be used specifically by DWAF personnel as a basis for negotiation with the mining industry, and likewise by the mining industry as a guideline as to what the DWAF considers as best practice in resource protection and waste management.
- Inform Interested and Affected Parties on good practice at mines.

The DWAF Best Practice Guideline Documents contain detailed summaries of the legislation, strategies etc. that is relevant to the mining sector.

Each Guideline document aims to promote the protection of water resources through preventing pollution at source and the application of cleaner production techniques.

It is highly recommended that use is made of these Guideline Documents.

There are three series of Guideline Documents:

- **A series** which relate to mining activities or aspects and address prevention and management of impacts. All guideline documents in the A series contain a summary of relevant legislation and best practice checklists relevant to the particular issue being discussed. These checklists can be used in conjunction with the checklists provided in Appendix 3 of this Guideline document;
- **G Series** which deal with general water management strategies, techniques and tools which could be applied cross-sectorally; and
- **H series** which deal with aspects of DWAF's water management hierarchy.

A list of the documents together with a summary of the aims is provided in **Table 2.3.** Copies of these Best Practice Guideline Documents can be obtained from the DWAF or downloaded off their web site **(www.dwaf.gov.za).**

Table 2.3: Summary of DWAF Best Practice Guideline Documents

Guideline Document	Summary of Aims of Document
Series A: Activity Guidelines	
A1: Small Scale Mining – User Format (2006) (available in English, Zulu and Sotho) Standard format also available for regulators	• To provide a simple guide to the licenses, permits or authorisations required by a small scale miner and to outline the responsibilities of the miner to ensure protection of water resources. Best practice information is provided to assist in reducing waste at source. • To describe the use of an Environmental Management Plan (EMP).
A2: Water Management for Mine Residue Deposits (2007)	• To provide practical guidance and steps on water management best practice over the full life cycle of the MRD or the mines MRD requirements. • To provide clarity on legal requirements and compliance and to provide guidance on the legal requirements for water management, in terms of the prevailing South African legislation.
A3: Water Management in Hydrometallurgical Plants (2007)	• To promote a strategic water management approach at hydrometallurgical processing plants; and • To provide a practical guide to optimizing water through pollution prevention at source and the application of cleaner technologies.
A4: Pollution Control Dams (2007)	• To provide guidance on water management best practice for PCDs including the planning, operation and integration into overall mine water management system. • To ensure that potential impacts on safety and the water resource are acceptable and managed over the life of the PCD.
A5: Water Management for Surface Mines (2008)	• To provide an overall context for water management which will illustrate the integration between water management in the broader catchment and the mine-specific water management • To provide practical guidance on the water management measures to be included in the mines Environmental Management Plan (EMP), Integrated Water Management Plan (IWMP) and Integrated Water Use License Application (IWULA) documents. • To provide practical guidance and steps on water management best practice over the full life cycle of a surface mine
A6: Water Management for Underground Mines (2008)	• To provide information to water managers with the mining industry that will provide clarity on information that DWAF officials will be seeking from them. • To provide a practical and logical process whereby water management within underground mining operations can be optimized. • To provide guidance on factors that need to be considered when planning for all life cycle phases and particularly closure of underground mining operations.

Table 2.3 continued

Guideline Document	Summary of Aims of Document
Series G: General Guidelines	
G1: Storm Water Management (2006)	• To provide a practical procedure to develop a SWMP and ensure compliance with targets and objectives. • To define where the expertise of suitably qualified persons is required at the various stages of plan development, implementation, operation and review/audit. • To reference relevant legislative and policy issues that need to be considered in a SWMP.
G2: Water and Salt Balances (2006)	• To define what should be contained in the balances and at what level of detail. • To define best practice for design, implementation and continuous management of a water and salt balance. • To provide an assessment of tools that can be used to develop water and salt balances.
G3: Water Monitoring Systems (2007)	• To provide clear guidelines on how to design and implement an effective monitoring programme that meets defined management needs. • To provide guidelines on how to interpret, manage and report the data obtained from implemented monitoring programmes.
G4: Impact Prediction	• To present the impact assessment and prediction framework and methodology based on risk assessment principles. • To provide specific guidance on the types of questions that need to be considered and answered when undertaking impact predictions and evaluating management options for different mining scenarios at different stages in the mine life cycle, in order that appropriate decisions can be made. • To provide guidance on the nature of a monitoring, predictive model validation and calibration programme and independent review. • To provide capacity building for DWAF officials in the review and understanding of impact prediction exercises.
G5: Water Management Aspects for Mine Closure (2008)	• To ensure that all stakeholders have their water resource-related interests considered during the mine closure process and to ensure that the closure planning process, from a water management perspective, is undertaken in a logical, orderly, defensible, cost-effective and timely manner throughout the mine life cycle. • To ensure that clear water resource-related closure objectives are defined and agreed upon and that these consider sustainable land use and environmental water balance issues. • To ensure that a set of indicators are established which will demonstrate the successful completion of the closure process and attainment of the agreed closure objectives in a sustainable manner and that will enable approval of the mine closure application process. • To provide guidance on information that DWAF needs to have access to in order to be able to review and assess a mine closure application.

Table 2.3 continued

Guideline Document	Summary of Aims of Document
Series H: Hierarchy Guidelines	
H1: Integrated Mine Water Management (2008)	• To present and promote the concepts and benefits of integrated mine water management throughout the mine life cycle, using practical examples to illustrate the application of the key principles. • To ensure that DWAF personnel, mining proponents and consultants understand the role of the BPGs and how and when to use them in implementing integrated mine water management. • To define the minimum contents of an IWMP, the level of detail required and the role of specialists in preparing and reviewing IWMPs.
H2: Pollution Prevention and Minimization of Impacts (2008)	• To ensure that pollution risks and pollution prevention opportunities have been identified, optimized and implemented during the exploration, planning, operation and closure phases of a mining project. • To ensure that measures implemented and decisions taken at any point in time, consider the effect of those decisions throughout the remaining life cycle. • To define procedures that can be utilized to identify and assess pollution prevention and impact minimisation management actions.
H3: Water Reuse and Reclamation (2006)	• To clearly define the process that should be applied by a mine when developing a mine water reuse and reclamation plan and that will be applied by DWAF when reviewing/evaluating a mine water reuse and reclamation plan within the bigger context of the mine's IWWMP. • To define the structure and content of a report or product that must be submitted to DWAF to enable the review/evaluation of the mine water reuse and reclamation plan or IWWMP.
H4: Water Treatment (2007)	• To clearly describe the technical methodology that should be applied by a mine to identify the constituents of concern that may require mine water to be treated to enable sustainable reuse or discharge (in accordance with an approved water use license, catchment management objectives, etc.). • To enable the mine to prepare the relevant sections of an IWWM plan that deals with water treatment.

CHAPTER 2: SUMMARY

√ Familiarise yourself with the various relevant legislation

√ Understand how cleaner production can assist you in complying with regulations and other requirements

√ Make use of the relevant DWAF Best Practice Guideline Documents

RECOMMENDED READINGS

√ DWAF Best Practice Guideline Documents (2006, 2007 and 2008)

3.1 What is waste and why reduce it?

Anything that goes into a process that does not come out as product or as input into another product is termed waste. This can be in the form of solid waste material, as well as emissions to air, land and water.

Waste takes many forms, including:

- Solid waste (also known as refuse)
- Waste water
- Effluent discharge
- Waste oils, solvents, liquid residues in drums
- Smoke and fumes
- Energy and heat loss
- Rejects and rework
- Wasted effort

Did you know?

The cost of your waste is not so much the cost of getting rid of it as the value of what you are getting rid of!

Source: UK Environment Agency (2001)

Waste costs more than you think!

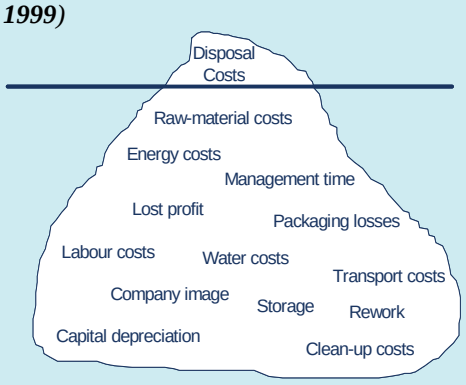
Many companies do not know how much money is wasted because the true environmental costs of a company are not known. Typically, only costs charged by external waste contractors are taken into consideration. Actual waste costs are often significantly more.

Hidden costs of waste include aspects such as:

- Loss of raw material
- Loss of water and energy
- Transport costs
- Rework costs
- Labour costs
- Time costs

The Waste Cost Iceberg:

Disposal costs are just the tip of the iceberg! (Source: Enviros Consulting, 1999)



Proper measurement of the costs associated with waste is thus vital as it is likely to convince management, as well as employees, that reducing waste can make money.

When implementing a Cleaner Production programme, determining the true cost of waste is an important exercise to determine potential savings (see Chapter 4).

3.2 What is Cleaner Production?

As a concept, Cleaner Production is synonymous with best practice environmental management.

It is a general term that describes a preventive environmental approach, aimed at increasing resource efficiency and reducing the generation of pollution and waste at source, rather than dealing with the waste once it has been produced.

Cleaner Production is a broad term, encompassing what is sometimes also referred to as waste minimisation, pollution prevention, or eco-efficiency.

In essence, Cleaner Production is about:

- Preventing waste and pollution at source
- Minimising the use of hazardous raw materials
- Improving water and energy efficiency
- Reducing risks to human health
- Saving money
- Improving efficient management practices
- Promoting sustainable development

Official Definition

"Cleaner Production is the continuous application of an integrated preventive environmental strategy to process, products, and services so as to increase efficiency and reduce risks to humans and the environment." (UNEP, 1990)

Cleaner production follows the waste management hierarchy and involves taking a pro-active approach such that the production of waste is minimised at source (see Figure 3.1). This will lead industry in the direction of sustainable development.

Previous approaches to dealing with waste were re-active and included:

- Ignoring the problem
- Diluting the problem to fall in line with discharge concentration requirements
- Treating the waste through the installation of end-of-pipe treatment technologies
- Recycling of some waste off-site

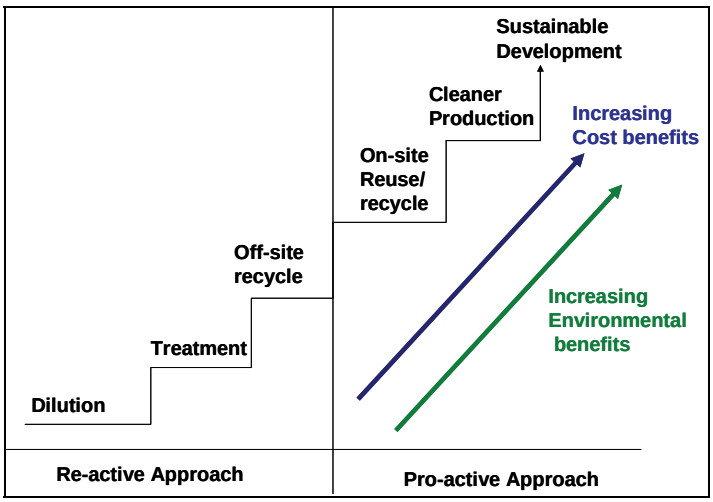


Figure 3.1: Waste management hierarchy and cleaner production

Cleaner Production can be achieved in a number of different ways, but the three most important of these are:

Changing attitudes: this involves questioning the normal operating practices and determining how efficiency can be improved, consumption of input materials and utilities lowered, and the generation of waste to land, air and water reduced. It means asking how operations can be conducted differently or better.

Applying know-how: This involves investigating the techniques used to carry out various processes. It includes implementing good management practices, better process control and improved housekeeping.

Making technology changes: This may involve making alterations to existing machinery or equipment, or investing in new technology to increase process efficiency and reduce environmental impact.

Some examples of how this can be achieved are provided in **Table 3.1**.

Table 3.1: Some examples of Cleaner Production interventions

Approach	Cleaner Production Opportunity	Examples of Actions
Changing attitudes	• Commitment to the programme from all levels of staff • Training • Improved communication	• Incorporate CP into in-house training programmes • Run regular awareness raising campaigns • Improve flow of information from one department to the next • Provide incentives for CP ideas • Use an information board to show-case CP projects
Applying know-how	• Housekeeping • Process control • Good management practices • Improved material storage • Raw material screening • Environmental monitoring	• Implement a monitoring and targeting programme to optimise utility use • Review and update water management plans regularly • Implement an energy management programme • Optimise process operations • Replace toxic raw materials with environmentally benign alternatives • Improve inventory management
Technology changes	• Equipment modifications • New technology • Preventative maintenance • Change in product formulation • Segregation of waste • Use of waste as raw material	• Undertake industry best practice surveys • Seek performance guarantees for critical equipment • Improve layout of equipment • Change products to meet customer needs

3.3 CLEANER PRODUCTION AS INTERNATIONAL BEST PRACTICE

Cleaner production is promoted world-wide as a means to achieving sustainable development. Some initiatives include (see also **Section 5.3**):

- The development of the concept of cleaner production by the United Nations Environment Programme (UNEP) in the 1990's;
- United Nations Environment Programme (UNEP) Division of Technology, Industry and Economics (DTI). The initiatives on mining, minerals and environment within UNEP DTIE are aimed at integrating environmental criteria into mining and mineral development, thus ensuring that the sector contributes to national development in the long term (sustainable development). Activities are focused on enhancing governmental and corporate policies and practices concerning mining operations, and to encourage leadership among key stakeholders concerning scientific, regulatory and technical development of the industry. (www.uneptie.org/pc/mining).
- The establishment of Cleaner Production centres in 24 countries around the world, including South Africa in 2002 during the World Summit. These are initially funded through UNEP and UNIDO (United Nations Industrial Development Organisation), after which they have to become self-sufficient within a designated number of years;

- The World Business Council for Sustainable Development is a coalition of 190 international companies with a shared commitment to environmental protection. This includes Cleaner Production and 'eco-efficiency'. Eskom and Sappi Limited are the two South African members of this global initiative.
- The Organisation for Economic Co-operation and Development (OECD – www.oecd.org) represents 30 highly industrialised and developed nations and incorporates Cleaner Production in its Sustainable Consumption and Production program. Member nations recognise the need to share information, including sharing it with developing nations.
- Encouraging governments, companies, business organizations, academia and non-government organizations (NGO) to sign the UNEP International Declaration on Cleaner Production. This International Declaration is a voluntary but public commitment to the strategy and practice of Cleaner Production. Guidelines for each of the above groups of stakeholders are provided. As of 2006, the only South African organisation to sign the declaration is the Water Research Commission.
- The provision of a Mining, Environment and Development website which provides and list (and free downloads) of a number of documents on mining and sustainable development from organizations such as the United Nations, World Bank, Environment Australia, etc. (www.natural-resources.org/minerals/cd/index.html).
- There are a number of activities undertaken within countries such as the United Kingdom, Australia, and America to promote cleaner production practices. Some of these include:
    - **Australia:** The Australian Government: Department of Industry, Tourism and Resources (www.industry.gov.au) has an excellent section devoted to the mining sector. Here you are able to download a series of booklets related to environmental best practice in the mining industry, some of which are referenced in this Guidance Document. Curtin University in Western Australia (www.cleanerproduction.curtin.edu.au) houses a Centre of Excellence in Cleaner Production.
    - **United Kingdom:** Envirowise (www.envirowise.gov.uk); the Environmental Protection Agency (www.defra.gov.uk); and the Carbon Trust (www.thecarbontrust.co.uk) are three excellent initiatives within the UK aimed at encouraging industry and business in increasing efficiency and reducing waste. Each site has a number of useful publications for download.
    - **America:** In the USA there are a number of initiatives underway to promote cleaner production and pollution prevention. Two useful resources include Envirosense – the US Environmental Protection Agency (www.es.epa.gov); and the Pollution Prevention Pays programme (www.p2pays.org).

Case study: Mount Isa Mines (Australia)

MIM Holdings Limited implemented a program of innovations which enabled the company to open a new mine and add new electricity-using activities while cutting total annual electricity use and carbon dioxide emissions. Interventions included:

- ***daily plant- wide energy forecasting and planning***
- ***smelter waste heat for electricity co- generation***
- ***recovered electrical energy from mine service water and chilled water***
- ***optimisation of ventilation systems***
- ***reducing peak loads (hoists)***

The following savings were achieved:

	Capital A$ (million)	*Savings A$ (millions/year)*
Turbines	*1.00*	*0.45*
Air conditioning	*0.5*	*2.00*
Mine processor	*0.5*	*0.40*
Ventilation	*0.02*	*1.10*
Hoisting	*0.02*	*13.0 (deferred expense)*
Energy management	*0.3*	*5% reduction in energy consumption*

Source: www.environment.gov.au/net/environet.html

3.4 Benefits of Cleaner Production

So why should companies implement a cleaner production programme? There are numerous benefits to cleaner production as is evident from the number of success stories and case studies available from all industrial sectors.

These include financial benefits such as:

- Improved process efficiency
- Reduced water, energy, raw material and chemical use
- Recovery of valuable by-products
- Reduced disposal costs of waste materials
- Reduced transportation costs for waste materials
- Increased returns by selling waste materials for reuse
- Reduced potential liabilities
- Potential marketing benefits
- Improved employee morale and productivity
- Improved recruitment and staff retention.

There are also environmental and health benefits such as:

- Improved environmental performance and compliance
- Reduced quantity of waste and effluent generated

Did you know?

- ***up to 87% of all Cleaner Production activities implemented are efficiency based;***
- ***half of all Cleaner Production measures pay back their own cost within a year;***
- ***90% of Cleaner Production activities repay their initial investment within two years;***
- ***up to half of all the Cleaner Production activities eliminated the waste;***
- ***more than 90% of the Cleaner Production activities contributed to increased product yield and/or reduced human resource requirements for the production function.***

Source: Environment Australia, 2000

- Reduced noise and pollution.
- Reduced transportation of waste
- Improved working conditions
- Improved motivation and morale
- Cost savings that frees up money which can be spent on other things (such as training)

Case study: Energy efficiency actions save money (Pajingo Operations, Australia)

Through optimising processes and equipment operation, the Pajingo site has made significant reductions in energy use and greenhouse emissions. Many of these modifications did not require spending a significant amount of capital and payback periods were consistent with normal business criteria.

Intervention	*Saving (MWh/year)*	*Environmental Saving (tons/year of CO_2)*
Optimise usage of current crusher circuit	*163*	*166*
Review of mine ventilation system	*3 178*	*3 240*
Review of compressed air system	*172*	*175*
Double handling of water	*240*	*245*
Float system on pumps	*83*	*85*
Reduction of idle time for mobile equipment	*13 kl/year of diesel*	*38*

Source: Environment Australia (2002): Extract from Case Study 4

Benefits of cleaner production to regulators

- ***CP reduces the problems and costs associated with waste management and disposal***
- ***CP assists local authorities to meet their discharge standards from municipal treatment works***
- ***CP helps authorities to meet their constitutional obligations to provide access to a clean and healthy environment***
- ***CP can help authorities to avoid the problems associated with the lack of landfill space and to reduce the high costs of building further landfills***
- ***CP helps avoid the high costs of having to build more dams in areas with scarce water resources***
- ***CP minimises the environmental impact of burning coal for electricity generation***
- ***CP reduces greenhouse gas emissions and city smog***

Source: Danida (2003)

3.5 Identifying and Overcoming Barriers

Despite the fact that cleaner production pays, many companies fail at implementing and maintaining a cleaner production programme. There are a number of different reasons for this, the most common being (Danida 2003*):*

- **Regulatory and incentive constraints:**
  - Inappropriately designed regulations
  - Tradition of poor enforcement of environmental regulations
  - Continuing shortage of capacity in key governmental departments
  - Low resource and waste disposal costs
  - Lack of consumer and shareholder pressure
- **Awareness constraints:**
  - Lack of knowledge and belief in the payback periods
  - Lack of technical knowledge and awareness of CP options
  - Perception of high risk involved in adopting unproven CP options
  - Lack of awareness of the available financing options
  - Lack of knowledge on environmental effects
  - Prevalent perception that waste management is a cost factor, rather than an opportunity for savings;
- **Operational constraints at the enterprise level:**
  - Lack of management commitment and political will
  - Low literacy rates amongst the workforce.
  - Low business confidence
  - Low business profitability
  - Payback periods exceeding the investment frame of the company
  - Close competitiveness resulting in a reluctance to share information
  - Management structures that impact on internal information

Ten Barriers to Creativity

1. ***Making mistakes***
2. ***being seen as a fool***
3. ***being criticized***
4. ***being misused***
5. ***being alone***
6. ***disturbing tradition and making changes***
7. ***being associated with taboos***
8. ***losing the security of habit***
9. ***losing the group's love***
10. ***being an individual***

Source: UNEP (1996)

In order to overcome these barriers, a company needs to identify the drivers to implementing a programme of cleaner production. These could include (*Danida CP Guide*):

- **External regulatory and policy pressures**
  - Effectively designed and enforced environmental regulation
  - Appropriate environmental tax and charge schemes
  - Requirements on companies to publicly disclose their emissions
- **The organisational characteristics of the individual firm**
  - Company size, with larger firms more likely to adopt CP
  - Strength of vision and leadership of top management in the organisation

- Nature of management and staff attitudes, including awareness and willingness to change
- Ability to access and willingness to share information for example through industry networks
- Nature of the firm's investment cycle noting implications for investment in CP technologies

Specific economic and market conditions for the individual firm

- Level of integration in the global economy, including impact of supply chain pressures
- Pressure for implementation of ISO 14001
- Comparative cost of raw materials, natural resources and energy
- The nature of the firm's investment cycle
- External structural issues relating to market certainty that may impact on investment decisions
- The nature of external consumer and community pressures

Case study: Barriers identified in South African Coal Mines

In a study on the implementation of cleaner production with coal mines in South Africa, the following barriers were identified:

- ***Difficulty in raising capital for new ventures***
- ***Behavioral and organizational change needed to allow for adoption of technological improvements (even proven technologies)***
- ***Lack of awareness on the concepts and values of cleaner technologies***
- ***Lack of infrastructure to allow for the implementation of technological changes***
- ***No project champion or project team elected to manage and facilitate cleaner production projects***
- ***Difficulty in obtaining performance data***
- ***Environmental managers too busy "keeping up" with legislative requirements rather than staying ahead of the requirements***
- ***No cleaner production aspects incorporated into mining legislation***

Source: Reddick, J (2006)

Table 3.2 provides further examples of barriers and methods of overcoming them.

Table 3.2: Examples of barriers and how to overcome them

(BECO-Institute for Sustainable Development)

Barrier	Ways of overcoming barriers
Conceptual barriers	
1. We have always done it this way! **2.** Environmental measures cost money, and prevention is only possible on the long term **3.** Why do we have to get involved in this now? Next month it will be something else again ('flavour of the month'). **4.** But we comply with all environmental legislation! **5.** We already do practice prevention, because we recently bought automatic doing installations for the departmental washing machines.	**1.** Present prevention as a challenge for positive development. Present examples. **2.** Present success stories of national and international colleague-companies. **3.** Reduce the resistance to change by presenting the change as a challenge and an opportunity. **4.** Savings are always interesting. **5.** Stimulate a pro-active attitude by pointing out stricter environmental legislation on the medium term. **6.** End-of-pipe seems like the quick solution. But is always more costly. Explain the difference between prevention and end-of-pipe.
Organisational barriers	
1. We have nobody to do this / This is not my responsibility **2.** That problem is not caused by us but by our suppliers **3.** We don't have time for prevention, because we need to make our production targets	**7.** Anchoring prevention in the organisation, so that environmental tasks and responsibilities are clearly spread. **8.** Start discussions with suppliers and clients about product specifications **9.** Production targets are often reached easier when prevention is anchored in the organisation.
Knowledge barriers	
1. We want to do something like this, but nobody knows anything. **2.** But how do we know that this will actually help us? **3**. Why would I practice prevention, I sell my waste for external recycling?	**10.** Gather information, e.g. from prevention advisors, internet or databanks. **11.** Collect references from companies where the installation/process functions already. Do your own investigation/research. Approach suppliers. Approach knowledge institutions. Approach your industry organisation. **12.** Income from external recycling rarely covers the real total costs of the waste stream. Often the recycling process and transport cause new wastes and emissions.
Economic / financial barriers	
1. We don't have money for cleaner production projects! 2. Payback period of 5 years? Much too long!	**10.** Cleaner production may sometimes cost a little on the very short term, but should pay itself back easily from the savings made on raw materials and waste costs. Try governmental subsidy programmes. **11.** Are you planning to close down in 5 years time? Five years is an internationally accepted payback period. Try governmental subsidy programmes.

It is a good exercise to determine the barriers to cleaner production within your own organisation / department at the beginning of your programme so that methods to overcome the problems can be identified. This can be carried out through brainstorming sessions with your team and through talking with staff members.

3.6 Steps to implementing Cleaner Production

Cleaner production is a continuous, systematic step-wise procedure to reducing waste at source. For this reason, UNEP developed guidelines as to how to implement a cleaner programme in 7 main steps. An explanation of each of these steps is provided in the following sections to guide your company through the main stages in implementing a cleaner production programme.

As a regulator seeking to promote cleaner production in a mining company, it is important to have a good understanding of the key elements and activities of an effective cleaner production programme

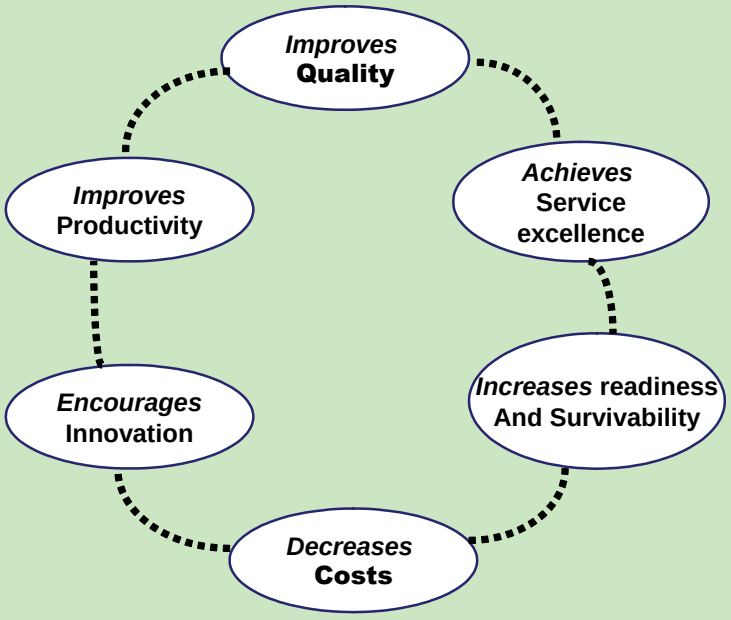
Most of the steps outlined below are accompanied by checklists/worksheets in **Appendix 1** to assist you in ensuring each step is completed successfully.

A structured Cleaner Production process can be broadly divided into the following steps:

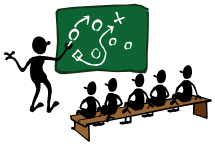
- Step 1: Planning and Organisation
- Step 2: Preliminary assessment
- Step 3: Detailed assessment
- Step 4: Identifying Options
- Step 5: Feasibility Analysis
- Step 6: Implementation
- Step 7: Monitoring and maintaining the programme

This is illustrated in **Figure 3.2.**

Cleaner Production: A Chain of Continuous Improvement



Source: UNEP (1996)



Step 1: Planning and Organisation

- Obtaining management commitment
- Electing a Project Champion
- Selecting a Project Team
- Identifying barriers
- Establishing programme goals

Step 2: Preliminary Assessment

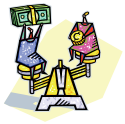
- Prepare process flow charts
- Undertake a walkthrough of the site
- Identify what waste streams are generated and where
- Obtain regulatory reports
- Obtain existing reports on the site
- Undertake a scoping audit
- Determine focus area(s)

Step 3: Detailed Assessment

- Collect and review data for focus area
- Collect missing /new data
- Undertake mass and energy balances
- Identify losses
- Set targets for reduction
- Identify training needs

Step 4: Identify Cleaner Production Options

- Review the waste streams
- Identify reasons for losses
- Brainstorm opportunities for improvement
- Review literature and case studies



Step 5: Feasibility Assessment

- Rank options
- Is option technically feasible?
- Is option economically feasible?
- Is option environmentally beneficial?
- Select most feasible option(s) for implementation
- Prepare report

Step 6: Implementation

- Plan and schedule
- Obtain capital if necessary
- Determine time scale
- Implement selected option(s)
- Undertake necessary training

Step 7: Monitoring and Maintaining the Programme

- Conduct regular reviews of cleaner production programme to ensure its running as planned
- Ensure continuous improvement by ***repeating steps 3 to 6*** over different areas of the operation
- Keep awareness raising programmes fresh and up-to-date
- Reset targets if necessary

Figure 3.2: Steps in implementing a cleaner production programme

3.6.1 Step 1: Planning and Organisation

Step 1: Panning and organisation:

- √ ***Get commitment***
- √ ***Elect project champion***
- √ ***Select project team***
- √ ***Identify barriers***
- √ ***Set overall goals***

The first step in initiating a cleaner production programme is to obtain **commitment from management**. Without this management commitment, no real action will take place and the programme will not be successful. One way of ensuring commitment is to have an **environmental policy** prepared for the company which states its commitment to reducing waste and pollution.

In order to ensure that the cleaner production programme is well managed and run, a Project Champion needs to be elected.

The responsibilities of the **Project Champion** include:

- Establishing project team
- Managing the programme
- Co-ordinating and facilitating the programme
- Reporting to management
- Training team members
- Disseminating results both internally and externally

Get your management committed by:

- ***Stressing the financial benefits of cleaner production***
- ***Stressing improvements to process efficiency and product quality***
- ***Undertaking a scoping audit***
- ***Citing compliance benefits***
- ***Providing case studies***

The personality of the Project Champion is also important, and he/she needs to be some-one who is:

- Enthusiastic
- Willing to learn
- Have credibility with management and shop-floor
- A good communicator and facilitator
- Able to overcome barriers
- Good at analysing data and reporting on results

Motivate your team(s) by:

- ***Involving them in setting targets and identifying options***
- ***Providing good communication on project needs and outcomes***
- ***Provide recognition for a "job well done"***
- ***Lead by example – " do as I do, not as I say"***

The Project Champion is assisted by a **Project Team.** This team has the responsibility of:

- conducting the waste surveys
- identifying problem areas
- brainstorming the problems
- identifying options for improvement
- selecting the most feasible projects
- implementing and monitoring the results

The size of your company will dictate the size of your team. You may also decide to create teams for each department / operational area. Team members may also change as the needs of the cleaner production programme change.

A good Project Team is cross-sectional:

- ***Mining***
- ***Engineering***
- ***Health, Safety and Environment***
- ***Management***
- ***Services***
- ***Processing***
- ***Finance***

Together with the team, possible **barriers** to the cleaner production programme should be identified and means of overcoming them discussed (see **Section 3.5**).

Overall objectives or goals of the cleaner production programme can also be set at this stage. These do not have to be too specific at this stage, but should encompass the broader aims of what you are trying to achieve. For example, general goals could be stated as:

- 'significant improvements will be made in factory productivity'; or
- 'wastewater and air pollution discharges will be significantly reduced'; or simply
- 'the environmental policy objectives will be implemented'.

Specific goals can be set for one or more areas of activity (once general goals are set) such as:

- 'an average of 10% reduction in wastes generated'; or
- 'a 30% reduction in air pollution discharges through improved processes'; or
- 'a 25% reduction in chemicals used through better inventory control'.

3.6.2 Step 2: Undertaking a preliminary assessment

Before developing options for change, teams need to have a good understanding of (*Australian CP Guide)*:

- amounts and types of raw materials used;
- toxicity and hazardous characteristics of materials used;
- technology, processes and production methods used;
- amounts and types of waste (solid, liquid and gaseous) generated;
- costs of raw materials and other resources such as water and energy;
- costs of waste (solid, liquid and gaseous) storage, treatment and disposal; and
- levels and efficiencies of production in terms of product per raw material input, production per person employed, and waste generation patterns.

Step 2: Preliminary assessment:

- √ ***Prepare process flow charts***
- √ ***Undertake a walkthrough of the site***
- √ ***Identify what waste streams are generated and where***
- √ ***Obtain regulatory reports***
- √ ***Obtain existing reports on the site***
- √ ***Undertake a scoping audit***
- √ ***Determine focus area(s)***

This type of information can be obtained by:

- Undertaking a **walk-through** of the site to observe operating practices within each operational section;
- Preparing a **process flow diagram** which lists each of the operational stages together with the inputs to the process, and the outputs from the process;
- Obtaining **copies of any previous reports** on water, chemical, energy and raw material use;
- Obtaining copies of any water bills, chemical orders, etc.
- Reviewing the chemicals used and investigating their toxicity by looking at the material health and safety data sheets.
- Obtaining copies of any **regulatory reports** that detail limits and requirements in terms of water and energy use, wastewater discharge, waste disposal and air emissions, etc. It is important to address any compliance issues along-side the cleaner production programme.
- Undertaking a **scoping audit** (see **Section 4.1**)

Once all this information has been gathered, you will need to decide on which areas to focus first. This decision can be based on which area:

- Has the highest costs (gathered from the scoping audit)
- Generates most waste
- Uses the greatest resources
- Has the most harmful / toxic wastes
- Has the most information available
- Contributes the most to non-compliance issues
- Where staff is motivated to implement changes
- Has the most opportunities for improvement and a high potential savings (a quick success story will further motivate management and staff to continue with cleaner production projects)

These can then be given a ranking per department or utility area (e.g. water, coal use, etc.) between 1 and 5, and those areas with the highest ranking are considered to be the ones on which to focus initial efforts. This could be either an operational section; or a cross-cutting issue such as energy use or slurry generation.

Case study: Pre-assessment procedure in South African coal mines

Studies undertaken in 5 coal mines in South Africa used a waste comparison procedure for determining the focus areas. A score of between 1 and 5 (where 5 was the most wasteful) was allocated to each waste stream in 5 different categories: quantity; cost; environmental impact/hazardous nature; potential for cleaner production (rated 1 to 3); and other (rated -1 to 2). These were scored according to the following criteria:

Quantity (t/year): > 1 000 000 (5); 250 000-1 000 000(4); 50 000-250 000 (3); 10 000-50 000 (2); 0-10 000 (1)

Energy use (kWh/y): > 15 000 000 (4); 10 000 000-15 000 000 (3); 5 000-10 000 (2); 0-10 000 (1)

Environmental impact: rated 1 to 5 depending on hazardous nature

Potential for CP: no ideas (1); low potential (2); high potential (3)

Other: compliance with present / known future regulations – yes (0); no (1)
safety hazards to employees or surrounding areas – yes (1); no (0)
existing reuse / recycle – yes (-1); no (0)

Once the scores had been totaled for each waste stream, the three highest were chosen as the focus areas for further detailed assessment

3.6.3 Step 3: Undertaking a detailed assessment

Once the focus areas have been selected, more detailed information must be collected for these areas such that **mass, water and energy balances** can be carried out and losses identified. Existing data for the focus area should be **reviewed** for its relevance – **missing data** can be then identified and a procedure put in place to collect this information.

Step 3: Detailed assessment:

- √ ***Collect and review data for focus area***
- √ ***Collect missing /new data***
- √ ***Undertake mass, water and energy balances***
- √ ***Identify losses***
- √ ***Set targets for reduction***

It is also important to recognise the **true cost of waste** for the focus area (see Section) as it includes not only the cost of getting rid of the waste stream, but all the wasted raw materials, water, energy, labour, etc.

It is important to **train** the people on the team and those that will be assisting in data collection so that everyone has understanding of why they are collecting the information and their role in the process.

If you are focusing your efforts on utility usage, a very powerful method of identifying losses and variances, and setting targets for reduction, is through implementing a **monitoring and targeting** programme (see **Section 4.3**).

Once all the data has been obtained, analysed, and losses determined, **targets for reduction** can be set for the focus area. The Project Team will then meet to brainstorm cleaner production options to achieve these targets.

Mass Balancing

The basic concept of mass balancing is:

What goes in must come out

Losses are calculated by:

Losses = inputs – outputs – stock changes

3.6.4 Step 4: Identifying options for improvement

Step 4: Identifying cleaner production options

- √ ***Review the waste streams***
- √ ***Identify reasons for losses***
- √ ***Brainstorm opportunities for improvement***
- √ ***Review literature and case studies***

The first step in identifying options for improvement is for the Project Champion, together with the Project Team, to **review the waste streams** and to identify the **root cause** of the losses. These are generally due to aspects such as product specifications, the technology used, the quality of input materials, etc. (Figure 3.3(a)). Once the team is satisfied that they have identified the root cause(s) of the waste stream, they can then look for **cleaner production improvement opportunities** within each of these areas (Figure 3.3 (b))

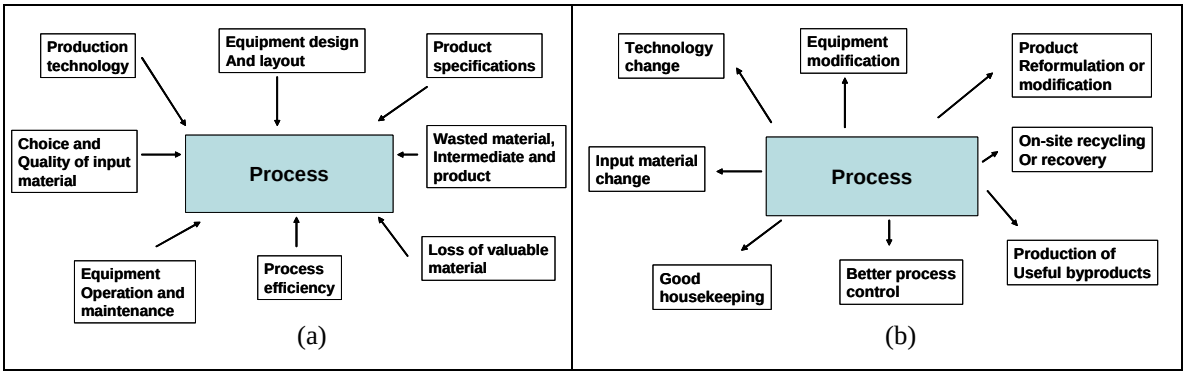


Figure 3.3: Causes of waste streams (a) and areas for generating cleaner production improvements (b) *(UNEP, 1998)*

Developing significant and potentially beneficial options will only occur by questioning current operational methods. The Project Team must ask themselves (and find answers to) questions such as (*Australian CP guide*):

Identifying the root cause

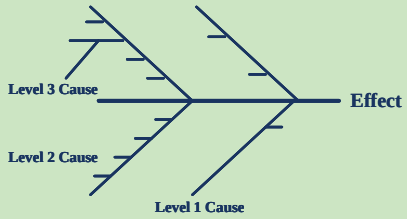
Identifying the root cause can avoid solving the wrong problem.

Ask WHY repeatedly

- ➲ why do we use this manufacturing method ?
- ➲ would a product design change use less raw materials?
- ➲ why do we use this chemical?
- ➲ how do our waste generation rates compare with industry standards or other subsidiaries of our organisation?
- ➲ are our procedures and staff training adequate?
- ➲ what alternative technologies are there for waste treatment and reuse?
- ➲ why has our water usage been increasing over the years?
- ➲ is there a better fuel for our heating processes?

Cause and effect diagrams

A useful way of keeping the team focused on solving the correct problem is through the use of cause and effect diagrams (or fish bone diagrams).



These diagrams are used when the symptom is clear but the causes are unclear, and to gain a common understanding of the problem

Literature and case studies can also be used to identify opportunities implemented at similar operations that may be applicable to the site.

All ideas coming out of such a **brainstorming** session should be captured and recorded. It is important to keep a record of all options at this stage as their feasibility may need to be assessed or reassessed later.

3.6.5 Step 5: Undertaking a feasibility assessment

The first step in undertaking a feasibility assessment is to rank the options in order to determine whether an analysis is necessary. In this way, the evaluation process is streamlined and unnecessary work is eliminated.

Step 5: Feasibility assessment

- √ ***Rank options***
- √ ***Is option technically feasible?***
- √ ***Is option economically feasible?***
- √ ***Is option environmentally beneficial?***
- √ ***Select most feasible option(s)***
- √ ***Prepare report***

You can start by separating the options into the various types (i.e. process changes, housekeeping, material substitution, etc.). Simple options such as procedural changes and improved housekeeping can be implemented directly after reviewing and training. Similarly, those options involving material substitutions can be implemented quickly if there are no major impacts on the production rate or product quality and if no equipment changes are required. However, those options which involve process and / equipment changes are more expensive and require in-depth investigations to ensure that they will operate successfully in the field. In this case, both technical and economic evaluations are necessary.

In all cases, an environmental feasibility should also be carried out to ensure that the chosen option will assist in compliance aspects, and to ensure that the implementation of the option won't cause other environmental impacts.

A **technical feasibility assessment** will answer the following questions:

- Can this be done or is this too far-fetched?
- Is the solution appropriate to the problem?
- Does it solve the problem or fix the symptom?
- Who will be able to implement the solution? (does it require external input)
- Is the relevant equipment available?
- Will it have an effect on product quality and productivity?
- What are the maintenance and utility requirements?
- What are the operating and supervising requirements/skills?

An **Economic Evaluation** includes an assessment of:

- Once off costs of implementation
- Ongoing cost of operating or maintaining the solution
- The financial benefits of improved performance

Calculating Payback

Payback is calculated by dividing the capital costs of an investment, by the net savings (gross annual savings less the annual running costs).

Investment and operational cost data will be required, so that you can calculate payback. A choice between the payback period, Net Present Value (NPV) or Internal Rate of Return will need to be made.

From an economic evaluation, the company should be able to:

- Identify the best investments
- Optimise the benefits of each investment
- Ensure minimum risk
- Analyse performance

When assessing the **environmental aspects** of Cleaner Production, one or more of the following needs to be considered (***Environment Australia, 2000***):

- benefits or adverse effects for current or future corporate environmental status and meeting internally set goals;
- benefits or adverse effects regarding regulatory requirements including greenhouse gas emissions; pollution discharges and hazardous substances;
- changes in hazardous materials use;
- changes in generating and discharging pollution and wastes (airborne, liquid and solid);
- life cycle assessment of materials and products; and
- occupational health and safety issues.

3.6.6 Step 6: Implementing the chosen options

Step 6: Implementation

- √ ***Plan and schedule***
- √ ***Obtain capital if necessary***
- √ ***Determine time scale***
- √ ***Implement selected option(s)***
- √ ***Undertake necessary training***

Those options that are found to be feasible can then go forward for implementation. When selecting an option for implementation, you must keep in mind what the outcome **must** achieve, and what you would **like** it to achieve in terms of cost, time scale, performance and disruptions to operations. Obviously if you need a result within 3 months, it is no use selecting an option that will take 6 months just to get out of the planning stage. As a minimum, only choose solutions that are going to meet the **must criteria** – those that achieve **both the must and like criteria** are the more desirable solutions.

Options that require equipment modification or the purchase of new equipment, will require planning, scheduling, designing, procurement, construction and commissioning. This will take time and also may require obtaining outside capital investment. All these aspects need to be taken into account when selecting the cleaner production option.

Options that require little or no capital investment can often be implemented as soon as they are identified – this often happens in the preliminary assessment stage. These tend to be housekeeping type solutions such as improved measurement and management of resources and materials.

Involving all relevant staff in the selection and implementation of cleaner production options will ensure ownership of the projects. For this reason it is important to **train** all operators that are going to be involved in the project in what is required from them and how to monitor the outcomes of the project.

3.6.7 Step 7: Monitoring and sustaining the programme

Step 7: Monitoring & Maintaining the Programme

- √ ***Conduct regular reviews***
- √ ***Ensure continuous improvement by repeating steps 3 to 6***
- √ ***Keep awareness raising programmes fresh and up-to-date***
- √ ***Reset targets if necessary***

Once complete, the project needs methodical monitoring, with results recorded in terms of the goals and objectives set earlier. The most important parameters for monitoring are likely to be changes in (***Environment Australia, 2000***):

- the use (and costs) of raw materials and energy;
- productivity and manufacturing efficiency;
- waste generation rates and costs;
- occupational health and safety incidents and absenteeism;
- environmental regulatory non-compliance incidents; and
- product quality in terms of product rejects and reworks, and customer complaints.

It is also important to track the outcomes from the project to ensure that it is achieving what was required. The team must identify what data is required to be collected and recorded in order to keep track of the following:

- Is the chosen option achieving the required environmental performance?
- Is the option providing the expected return on investment?
- Is the option performing as expected in terms of production efficiencies?

Recording the results and reporting on the success of the implementation of a project will assist in maintaining the motivation to continue with the cleaner production initiative.

Cleaner production is a **continuous improvement** programme and you must therefore keep repeating the assessment steps within each area / department within your organisation to identify further opportunities for improvement and savings. Continuous monitoring of the results is important – as soon as current targets are met and maintained, **reset the targets** to encourage further improvements.

Awareness raising (see **Section 4.4**) within all levels of staff is also important to keep the momentum going and to sustain the programme. Cleaner production must become a way of life for all employees and be incorporated into **business as usual**.

CHAPTER 3: SUMMARY

- √ Understand each stage of implementing a cleaner production programme
- √ Identify your role in implementing cleaner production
- √ Select a dedicated project champion
- √ Select a cross-functional project team
- √ Use the worksheets in Appendix 1 to assist you in each stage of the programme

RECOMMENDED READINGS

Environment Australia (2000); Danida (2003); UNEP (1996)

Chapter 4: Some Tools of Cleaner Production

There are a number of tools that will assist a company in implementing a cleaner production approach. These include:

- Undertaking a scoping audit
- Identifying the true cost of waste
- Implementing a programme of monitoring and targeting
- The importance of providing training and raising awareness
- Becoming a member of a cleaner production forum
- Taking a life cycle approach

More information on each of these tools is provided in this Chapter.

4.1 Undertaking a Scoping Audit

One of the first steps in implementing a cleaner production programme is to obtain the commitment from senior management. One way of doing this is through providing an indication of the possible savings that can be made through cleaner production. This can be achieved by undertaking a scoping audit.

A scoping audit involves collecting financial data for each input to the company such as raw materials, water, energy, chemicals, etc. and for each output; e.g. waste cost disposal, effluent treatment, etc. These should be broken down into as much detail as is possible based on the financial records for the previous year and placed under the relevant sections given in the table in the box on the right hand side of the page.

An expanded table can then be prepared as shown in Table 4.1 where the annual cost and the annual quantity (if available) can be entered. The range of possible savings can then be calculated based on the percentages given in the scope to save columns.

This scoping audit therefore assists you in:

- Identifying where the greatest costs lie within your company / department
- Identifying where the greatest potential savings lie
- Identifying the focus areas for your investigations (by using these results in conjunction with those from the preliminary assessment)
- Breaking down the costs of the company and giving you an indication of where money is spent and in which area – often the people on the project team do not ever see this bigger picture and it initiates the questioning process right from the start of the programme.

What is a scoping audit?

- ***List all inputs to, and outputs from the mine under the headings given in the table below***
- ***Identify the annual cost of each of these based on the previous financial year***
- ***Identify the potential savings through implementing cleaner production based on % savings given in the table below***
- ***This audit gives an indication of where the most money was spent and also where the most potential financial savings lie***

Utility	Scope for Saving (%)
Raw materials	1 to 5
Packaging	10 to 90
Ancillary materials	5 to 20
Consumables	10 to 30
Electricity	5 to 20
Heat for process heating	10 to 30
Water	20 to 80
Effluent	20 to 80
Solid Waste	10 to 50

Source: Enviros Consulting (1999)

Case study: Scoping audit motivates management

The project champion from a South African Textile company undertook a scoping audit for his operations. The potential savings were so impressive, that the managing director created a new position for a cleaner production project co-ordinator and challenged the project champion to go out and achieve the savings. To date, this company has saved 4% of its annual turnover, has an excellent awareness raising programme in place and continues to investigate options for improvement and make savings.

Table 4.1: Example of a scoping audit table

Resources & Services	Quantity	Units	Cost/year	Priority (1=Highest)	Scope to Save	Scope	Scope
Raw Materials	**Quantity**	**Units**	**R**		**%**	**R(min)**	**R(max)**
First most used					1 to 5		
Second most used					1 to 5		
Third most used					1 to 5		
Other Materials							
Cyanide					5 to 20		
Flocculant					5 to 20		
Magnetite					5 to 20		
Consumables							
					10 to 30		
Energy							
Electricity					5 to 20		
Diesel					10 to 30		
Gas					10 to 30		
Water					20 to 80		
Effluent					20 to 80		
Solid waste disposal					10 to 50		
TOTAL							

4.2 IDENTIFYING THE TRUE COST OF WASTE

As discussed in Section 3.6, it is important to identify the **true cost of waste** for your site. Many companies only see the cost of waste disposal as the cost of their waste, but as the waste-cost iceberg demonstrated, there are many other factors that need to be taken into account when calculating the cost of waste generated at your site. These include:

Did you know?

Waste disposal costs are just the visible cost of waste. Its true cost can be up to 25 times the cost of disposal and potentially up to 4.5% of a company's annual turnover.

Source: Danida (2003)

- **Loss of raw materials** – Waste that leaves the company carries the raw material value and is a loss to the company. This loss is calculated as the amount (in tons) of each waste stream leaving the plant multiplied by the price per ton of raw materials.
- **Loss of added value** – if waste is internally or externally recycled in a company and reworked the amount of energy and water that went in to make the waste in the first place is lost. This is expressed as the loss of "added value". This loss is calculated as the amount (in tons) of each waste stream leaving the plant multiplied by the added value per ton of product.

- **Energy and water costs** – Cost that is lost for each ton of waste since it carries an amount of water and energy that could have made a "product" instead. For reworked wastes the energy and water costs are charged twice.
- **Internal treatment** – the amount of waste stream in tons (internally recycled) multiplied by the recovery cost in (R/ton). This is based on the salary of the worker working in the treatment process (might include) also an estimated wear and tear of the machine.
- **Income from selling** – this must be included in the true cost of waste calculation as it off-sets the other costs and is entered as a negative.

Examples of "wastes" in the South African mining sector

- ***Uses 8% of the total energy consumed in SA (electricity, gas, coal and petrol products)***
- ***On average, a coal mine uses 133 litres of water per ton of ROM coal mined***
- ***Coal slurries contain water and product***
- ***Methane which could be recovered and used as an energy source is discharged***
- ***Loss of chemicals in waste discharges***

Source: Reddick, J (2006)

Remember to also include the obvious costs of waste such as effluent treatment costs, solid waste disposal, etc.

Case study: True cost of waste shows loss, not profit! (*Beco*)

In the example provided in the table below, this company manufactured peanuts and sold off any damaged goods. When asked what their cost of waste was, they replied that they were actually making a profit from their waste as they sold off any damaged peanuts at a reduced cost, and also their used oil. However, what they had not taken into account was the true cost of waste; i.e. the loss of raw materials, the loss of added value, the disposal of bags and the treatment costs. When added up, this company was actually losing over R2 million per year, rather than making the R74 000 that they thought from the sale of rejects.

Waste / emission	*Quantity per year*	*Cost in Rands*				*Total costs per year*
		Internal costs			*External costs*	
		Raw material loss	*Loss of added value*	*Internal handling / treatment*	*Transport and disposal*	
Process waste						
Peanuts	*310 tons*	*R310 000*	*R775 000*		*- R31 000*	*R1 054 000*
Empty bags	*9 tons*				*R11 250*	*R11 250*
Frying oil	*260 000 l*	*R1 365 000*		*R240 625*	*- R65 000*	*R1 440 625*
Wastewater						
Waste water	*500 kl*	*R3 250*		*R187 500*	*R9 975*	*R200 725*
Cleaning chemicals	*5 000 l*	*R50 000*				*R50 000*
TOTALS:		*R1 728 250*	*R775 000*	*R328 125*	*- R74 775*	*R2 756 600*

4.3 The Importance of Monitoring and Targeting

Monitoring and targeting is a powerful tool in the management of utility consumption within an industrial process. Initially introduced as a tool for energy management (electricity (compressed air); steam, oil, etc.), it has also been successfully applied in the management of water use. This section will give a very simple explanation of the concept. For more detail, please refer to the publications given in the **recommended readings** section.

The basic principles of a monitoring and targeting programme are:

- Measure consumption (e.g. water / electricity use)
- Measure variable (on which consumption depends; e.g. production / production hours)
- Compare consumption to variable (x-y scatter plot)
- Set targets
- Report on results

Potential savings through implementing M&T

Electricity	***3%***
Steam	***5%***
Water	***5-10%***
Compressed air	***10%***
Gas/oil	***5%***

(Source: Enviros, 1999)

In order to measure consumption, the utility being monitored obviously needs to be metered. The first step is to therefore identify where meters should be placed. This is determined through a preliminary audit where consumption in each area is estimated and major users identified. The number of meters that should be installed depends on the annual cost of the utility you want to monitor, the cost of the meter, the estimated potential savings and the payback required.

Once the meters have been purchased and installed, you need to determine what variable you are going to use to measure consumption against. In many cases this is something simple such as production, or production hours, but it may be more complex depending on your operation. Selection of the right variable is important, otherwise target setting will become meaningless.

Once the variable has been selected, you can initiate your monitoring and targeting programme. This involves taking meter readings on at least a weekly basis (daily or per shift can also work, depending on the level of detail required) and measuring the variable at the same time. Both monitoring periods must be exactly the same otherwise the comparison becomes meaningless.

Plot the consumption data versus the variable data on an x-y scatter graph. If the variable has been selected correctly, this should show a relationship similar to the one given in **Figure 4.1**. The best-fit line provides an average of all the data points, and then becomes the **target equation**. In other words, you want to aim to have all the data points falling onto, or below this line.

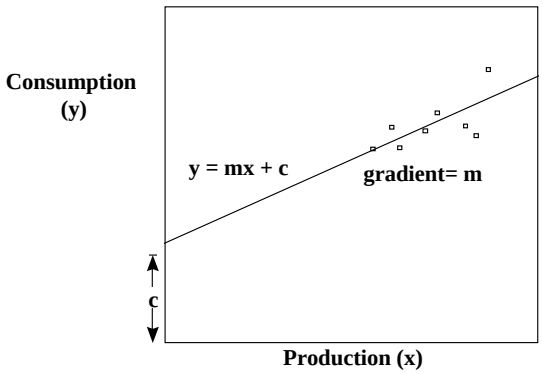


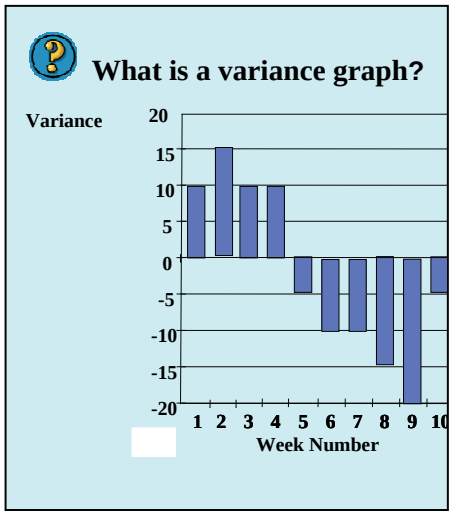
Figure 4.1: Example of an x-y scatter plot

This graph gives the following information:

- The equation of the line is given as y = mx + c, where c is the intercept and m is the gradient of the line.

- The intercept, c, represents the amount consumed at zero production. This is called the **base load**. One of the first steps in analyzing the data is to determine why this base load exists.
- The gradient of the line, m, gives an indication of the amount of utility required to be consumed per unit production.
- The scatter of the points gives an indication of the control over the process. The greater the scatter, the less the control; e.g. for the same production, there can be various consumption data points.

By using the target equation, you can now on a weekly basis determine how much utility you should have consumed for the amount of product produced. In other words, substitute the calculated gradient (m), the intercept (c) and the production for that week (x) into the equation and determine y. Compare this value to the amount of utility actually consumed and determine if you over or under consuming compared to this target.



This difference is termed the **variance**, and can be plotted on a weekly basis. Where variance is negative, it means that you are performing better than the target (as variance = actual data – target data), while a positive variance means that you performing worse than the target (i.e. using more utility than you should based on the target equation).

The reasons for this variance can then be discussed by team members and corrective action taken.

To determine the performance of the monitoring and targeting programme over a period of time, a CUSUM (cumulative sum) plot of the results can be prepared (**Figure 4.2**). This involves adding together all the variances over the time period and plotting them against time. Any changes that have been made within the project lifetime to correct any problems will be shown in the change in the direction and gradient of the curve.

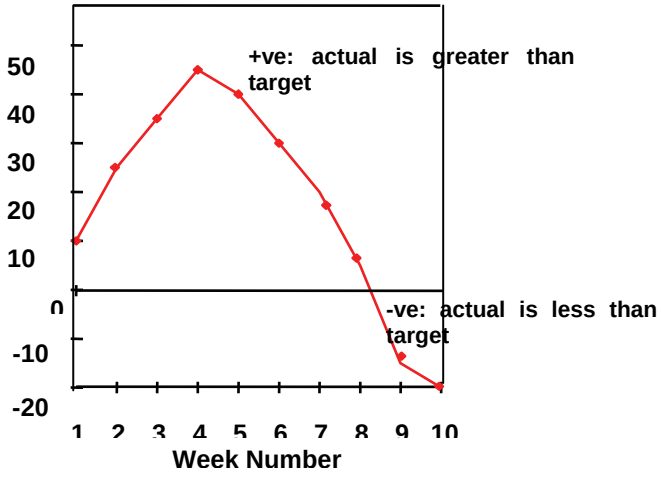


Figure 4.2: Example of a CUSUM plot of utility use on a weekly basis over 10 weeks

These CUSUM graphs can be plotted as either consumption, or as Rands as shown in Figure 4.2, some action was taken in week 5 that allowed this company to start making savings rather than a loss. However, it took them 8 weeks to recuperate the losses that they had made over the first 5 weeks.

Case study: Monitoring and targeting in a Quarry

Pedreiras Valéria (PeVal) is a quarry located near Salvador in Bahia. Processes are drilling and blasting rock, loading of rock into tipping trucks for transport from the excavation face to the manufacturing areas where the rock is crushed, milled and screened by size to produce stones of six sizes, before storage and sale. PeVal was one of six sites which participated in a project to demonstrate M&T in Brazil under the European Union Thermie project and the World Bank ESMAP programme.

The following steps were followed in implementing the M&T programme:

- ***A review of current metering systems***
- ***Installation of additional metering and M&T software***
- ***Project champion elected to manage and run the programme***
- ***Review of data undertaken regularly and appropriate action taken***

Savings were realized in electricity use in the rock crusher, compressed air system, lighting and air conditioning. Diesel use by the trucks was monitored in relation to the quantity of rocks trucked and an energy efficiency priority order could be established. Overall, savings of 17% of the company's energy bill were realized for minimal investment.

Source: European Commission THERMIE project (date unknown)

4.4 Training and Raising Awareness

Two important aspect of maintaining a cleaner production programme are training and awareness raising. Without these interventions, the programme will fail due to a lack of support and involvement of all staff at all levels. This section highlights some of the aspects that need to be taken into account when planning training and awareness raising within an organisation.

4.4.1 Training in cleaner production

The first step in planning a training programme is to determine:

- Who needs to be trained
- Who will do the training
- When will the training be carried out
- What level of training is required
- What training material is required

An example is given in Table 4.2.

There are numerous presentations, guides, manuals, case studies and exercises available locally and internationally that can be drawn on to assist in developing a training programme and training material. Refer to **Recommended Readings** at the end of this chapter as well as in **Appendix 4** for more information.

Table 4.2: Example of identifying training requirements for an organisation

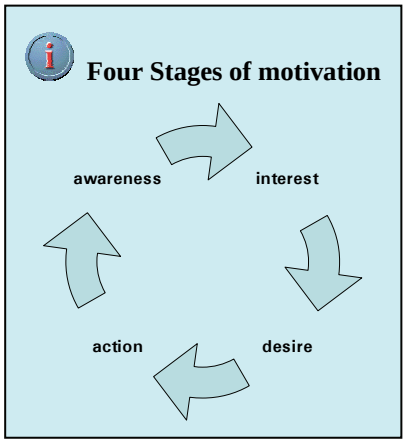
Questions	Some Recommendations
WHO will be trained?	√ Senior and middle management √ All process engineers √ Project champion √ All team members within each section
WHO will do the training?	√ Self-training by use of training manuals √ External cleaner production trainers √ Project champion
WHEN will training take place?	√ When a new team members is selected √ When middle management is replaced
WHAT training is required?	√ Once-off followed by annual update √ Middle and senior management to have general CP training in methodology and benefits √ Process engineers and project champions to have technical training
WHAT material is required?	√ A book of training material based on cleaner production methodology √ Videos and CDs √ Case studies and examples

4.4.2 Raising awareness

Besides a targeted training programme as described in the previous section, general awareness raising activities need to be conducted to inform all staff members at all levels of the cleaner production initiatives underway, and their role in making the programme a success.

The aims of raising awareness are to:

- **Obtain commitment:** Staff awareness of the goals and benefits of cleaner production will encourage support and remove barriers
- **Obtain input to measurements:** Staff awareness of the purpose of measurements will help ensure that accurate data is collected
- **Generate improvement options**: Staff awareness and participation will be essential for brainstorming and suggestion schemes



The only thing worse than low awareness, is poor awareness from a badly planned campaign. We've all experienced the usual 'put a few posters up and make it look like we're doing something' approach. Posters can make people aware but if used in isolation will not necessarily achieve commitment and motivate them into taking a specific action.

There are four stages to developing the motivation for staff to take action – awareness, interest, desire and action. To begin with staff should be made aware of the issues and what they can do. If awareness raising is done effectively it will also stimulate interest and desire which will lead to action.

A key component of a successful awareness campaign is having a clearly thought through Action Plan. The aspects that should be addressed through an action plan include:

- **Why:** Identify the key reasons / drivers for the campaign, e.g.: to reduce the costs associated with waste and the company's environmental impacts.
- **What:** Define the focus of the campaign, e.g.: solid and liquid waste, reducing rejects or ISO14001 development. Set your objectives and targets for the campaign. Define the target message and what you are asking people to do – is it to volunteer for teams, put forward suggestions, or be more vigilant? Staff can be motivated by a range of factors so the campaign messages should address:
  - the environmental impact of resource use and waste creation
  - the importance of minimising waste to the company
  - practical guidance for individuals to reduce their environmental impact at home and in the workplace
- **When:** Set a launch date for the campaign. Decide on a timescale for the campaign – how long will it run for, how frequently to publish newsletters, etc. An awareness campaign can be short-lived to stimulate ideas, or it can be an ongoing campaign.
- **Who:** Decide who needs to know and what sort of messages would appeal to them. If you have a large site, try to set up a steering committee with representatives from all areas. These 'Waste Wardens' should be given a degree of freedom to develop their own ideas within the overall framework and then new ideas will be developed that can be shared across the site
- **How:** Decide which tools you are going to use at each stage of the cleaner production process. Identify the campaign costs – don't forget printing, stoppage time for training sessions, prizes for suggestions. Decide how to 'end' the campaign. This may not be a total end to the campaign, but an end to the special focus of the campaign. To launch your campaign you could consider:
  - a quiz, competition or crossword to raise awareness and gauge staff support and knowledge. Competitions will also stimulate discussion amongst staff.
  - staff briefings
  - posters and newsletters

Remember to use a common language so that all staff can understand the message being given.

It is also important to assess the success of any awareness raising campaign. Some ways in which this can be done include:

- Identify savings, which are directly as a result of the campaign, both environmental and financial
- Carry out a "before and after" audit
- Ask staff for feedback
- Use a quiz to determine the level of awareness and before and after the campaign

Report on the results of the campaign so that all staff is aware of the contribution that they have made to the programme.

Again, there are numerous publications that can assist you in preparing an awareness raising campaign for your organisation. Refer to **Recommended Readings** at the end of this chapter as well as in **Appendix 4** for more information.

Case study: BHP Raise environmental Awareness

BHP Coal

BHP Australia Coal Limited (BHP) is committed to integrating environmental concerns into its management system.

BHP, in association with the Queensland Vocational, Training and Employment Commission for Accreditation, has developed a self-paced and self-directed competency-based training program. The program comprises over 100 training modules. The training modules appropriate to individual employee needs are identified during the Career Development Planning process.

The competency-based training program includes such environmentally related topics as:

- hazardous substance usage;
- managing the work environment;
- reclamation and rehabilitation; and
- managing water supplies.

Additional modules are developed according to need. A typical training module lasts about 30 hours. Half of the training is out of work hours, demonstrating a shared commitment from both parties.

Assessment is through written tests and observation of competency in an auditing process. Demonstration of competency results in national certification for competence under the National Framework for the Recognition of Training.

As a consequence of competency-based training and awareness, employees who complete agreed modules can look forward to:

- an increase in pay scale;
- being scheduled onto other equipment leading to greater career opportunities;
- peer recognition; and
- improved recognition and employment opportunities within the mining and petroleum industry.

Source: Environment Australia (1995(b))

Case study: Example of an awareness raising action plan

Campaign Name	*Environment Action*
Reason/driver for an Awareness campaign	*To reduce the costs associated with waste and the company's environmental impacts*
Campaign Manager	*Health and safety manager*
Objectives	*To enlist staff support to waste minimisation and remove barriers to change* *To raise staff awareness of the environmental impact of waste raw materials, water and energy* *To raise staff awareness of the costs of waste to the company* *To encourage staff to take action to reduce waste – to identify areas of wastage and implement changes to reduce it* *To engender a culture of continuous improvement*
Targets	*All staff to understand the company's objectives with regard to waste minimisation by March 2002* *5% reduction in (specify particulars) raw material usage through improved housekeeping measures by April 2002* *10% reduction in water and energy usage through improved housekeeping measures by April 2002*
Inputs required from staff	*Identify areas of wastage; e.g. spills, leaks, faulty equipment and put forward suggestions for reduction via a suggestion scheme* *Implement actions already identified as needing addressing; e.g.:* *Switch off equipment / lights when not in use* *Switch off hoses / taps when not in use* *Segregate wastes – cardboard, metals, plastics, wood* *Contribute to discussion / brainstorming sessions*
Start and end date	*October 2001 to March 2002*
Tools to be used	*Staff competition and quiz to launch the campaign. (Results of quiz will also be analysed to assess awareness at start of the campaign). All staff who complete and return the quiz will be given a free low energy light bulb for use at home.* *Team meetings: waste minimisation will be an agenda item at all weekly team meetings before, during and after the campaign. Information will be discussed with, and provided to, the team leaders by the campaign manager. The campaign manager will attend team meetings from time to time to answer any queries that arise, obtain feedback, etc.* *Posters will be displayed on notice boards, canteen, toilets, changing rooms, doors, to remind people of what they should be doing; i.e. making suggestions, switching equipment off, segregating wastes, etc.* *Newsletters – a regular section to report on the progress of the project will appear in the company's monthly newsletter* *Pay slips – amazing environmental facts will appear on pay slips to remind people what they can do at home* *Suggestion scheme – a suggestion scheme will run for the 6-month period to get ideas from staff on were wastes are occurring and how to reduce waste. All suggestions will be acknowledged within 10 days and initial feasibility assessed (with feedback to the originator) within 6 weeks. All suggestions implemented will receive a gift token – the value of which will depend on the scale of the cost savings*
Monitoring	*A quiz will be used at the end of the campaign in March 2002 to assess the effectiveness of the campaign in raising awareness and to check that all staff understand the company's objectives with regard to waste minimisation. Staff will also be asked for feedback on the campaign so that lessons can be learned for any future campaigns.* *Raw material, energy and water usage reductions that are directly attributable to the campaign will be measured – cost and environmental benefits*
Exit strategy	*The results of the campaign will be reported to staff via team briefings, the companies newsletters and posters on notice boards etc.* *Key performance indicators will be developed and reported to staff on an on-going basis*

Source: UK Environment Agency

4.5 CLEANER PRODUCTION FORUMS

Cleaner Production Forums (CPF) is the name given to a group of companies that meet on a regular basis to exchange information and ideas on cleaner production. These CPFs are generally facilitated by an external consultant with cleaner production experience, and who is responsible for arranging the meetings, training the members in cleaner production methodology, and facilitating the discussion sessions. In some cases, the facilitators will also assist the companies in undertaking audits of their sites.

Did you know?

Cleaner Production Forums (CPF) are also known as Waste Minimisation Clubs (WMC) in South Africa and other parts of the world. There have been more than 20 WMC in 10 industrial sectors and 7 industrial areas. The term CPF was coined as part of this project as it better reflects what needs to be achieved in the mining industry.

Pilot WMC in South Africa within the metal finishing industry and a cross-sectional forum in Hammarsdale in 1999 resulted in financial savings to the 20 member companies of over R13 million /year. Water and energy use was reduced and there was a reduction in chemicals and metals discharged to drain.

Source: WRC (2006)

The concept of CPFs (or Waste Minimisation Clubs as they were first known) was first developed in the United Kingdom in the early 1990s due to problems with the poor water quality of the rivers in industrial areas. Companies had to investigate methods of reducing waste at source, or face hefty penalties. The first CPF was therefore established within a group of companies discharging to the same river basin to discuss how these issues could be addressed. This resulted in the companies achieving significant financial savings, as well as an improvement in the river water quality. Since this time, numerous CPF (or similar concepts) have been established in the United Kingdom, New Zealand, India and South Africa.

These forums can be cross-sectional (companies come from different manufacturing areas) or sectional (companies from the same manufacturing area). Meetings are generally held every 6 to 8 weeks. In some cases these CPF are funded externally, and in others, the members of the CPF contribute towards the costs of running and managing the forum.

4.5.1 Forming and Running a Cleaner Production Forum

There are 7 stages in forming a CPF (***WRC, 2007***). These include:

- **Identifying the need for a CPF** – there may a number of drivers for the formation of a CPF, such as reducing environmental impact of a particularly polluting industrial sector; improving water quality within a river catchment area; or to raise awareness on cleaner production issues and to assist companies in reducing waste and saving money.
- **Raising awareness** – once the need for a CPF has been identified, the next stage is to inform the companies of the concept and benefits of a CPF.
- **Recruitment** – This is an important stage in forming the CPF. The potential members need to be identifying and recruited. This can often be carried out in collaboration with an industrial association such as the Chamber of mines.
- **Organisation for action-** In this stage, the club structure and management roles are discussed and the format for the club meetings arranged.
- **Assessment** – This is the longest stage in the running of a CPF, where on-site audits are carried out to determine savings (both environmental and financial). Training is provided by the club facilitator in how companies undertake data collection and analysis.
- **Implementation** – This step involves implementing the cleaner production actions that were identified as an outcome of the previous stage.
- **Analysis** – This is an important stage in the CPF process and should be carried out by the facilitator to quantify the results and successes from the club such that lessons can be learnt for further clubs.

The Facilitator Manual developed under the Water Research Commission (WRC) sponsored project (***WRC, 2007***) deals with each of these stages in more detail.

4.5.2 Barriers within a Cleaner Production Forum

Barriers that are typically experienced within a CPF member companies are the same as those discussed in general terms in Section. In addition to these there may be barriers that are specific to the running of a CPF, some of which are listed in Table 4.3.

Table 4.3: Barriers experienced in running a cleaner production forum (WRC 2007)

Barrier	Suggestion to overcome
Non-attendance at meetings and training sessions	- hold meetings at convenient time and location for all members - ensure commitment from senior management - set a minimum attendance - meet at a club members site on a rotational basis
Lack of REAL commitment	- use local case studies from the same industrial sector - make one-on-one visits to management - get endorsement of the concept from another industrialist - show success from a competitor - have an early success to get management on board - identify the true cost of their waste
Lack of progress on-site	- walk-through audit - provide access to assistance - train in small stages - undertake site visits to other factories - identify quick-wins - set achievable tasks for the member - provide starting points - facilitate a brainstorming session in the company to overcome barriers - disseminate results on-site
Poor success in recruitment stage	- get commitment from management - identify the decision maker in the company - identify the correct timing for that Club - find pressure points / interest areas - realise that you cannot force a Club and recognise when to give up
Competition between Club members	- emphasise that it is information on waste minimisation that is to be shared - companies only need to share what they are comfortable with sharing
Lack of perception of the need for cleaner production	- provide success stories
Obtaining data from companies	- sign a confidentiality agreement - accept limitations of what the company wants to report to you
Hijacking of meetings by a member	- try to re-direct discussions - limit time per company within reason - monitor reactions from other members to see level of interest
No *big stick*	- involve the local authority - emphasise the benefits of cleaner production

Barriers to both the CPF concept and cleaner production can be overcome in time through:

- Training and awareness
- Success stories
- Reporting on results from within the CPF

- Meeting with management
- Encourage management to communicate commitment to all levels such that the Project Champion receives assistance
- Allowing time for the CPF to mature and relationships to develop
- Discussions with local authorities

Case study: Cleaner Production Forum in the Coal Mining Industry

The South African Water Research Commission (WRC) funded the establishment, management and running of a cleaner production forum in the coal mining industry in the Witbank area. This CPF was facilitated by BECO-ISB, who was responsible for arranging the meetings, providing training, assisting in undertaking cleaner production audits, and preparing newsletters on the results of the CPF. This forum was established in July 2005 and consists of 5 coal mining companies; namely Total Coal, Xstrata Coal; Sasol Mining; Kangra Coal and Anglo Coal.

Meetings were held every 2 months and students were employed to gather data in the participating mines. Focus areas were then chosen in each of the mines for further in-depth analysis. Training in cleaner production aspects was provided by the facilitator, and guests were invited to give relevant presentations at each of the meetings. Regular newsletters were also prepared to provide the member companies with an update on the progress with the CPF and to provide information on other relevant environmental and cleaner production issues.

Some of the topics covered at the meetings included:

- ***Discussion of Key Issues in the Coal Mining Industry***
- ***Training in each stage of implementing cleaner production***
- ***Feedback on the results of audits in participating companies***
- ***Flow Measurement in the Coal Mining Industry – by Craig Martens of Flowmetrix SA***
- ***An Opportunity for Fine Coal Utilisation –by Mike Blenkinsop of WERM***
- ***Brainstorming of solutions***

Results from the CPF included:

- ***Identification of cleaner production opportunities within member mines***
- ***Feasibility assessments of selected cleaner production options***
- ***Financial and environmental savings***

A second CPF was established in the Gold mining sector.

Source: Reddick J (2006) and minutes of the CPF meetings available from BECO.

4.5.3 Benefits of a Cleaner Production Forum

The benefits of being of a member of a CPF include:

- Exposure to training in cleaner production methodology
- The interaction with other companies with similar environmental pressures and requirements
- The exchange of information and ideas on cleaner production which may be applicable to your own operations
- Access to information, advice and assistance that may not have been available previously

Encourage companies to become members of a cleaner production forum as this will assist you in achieving your aims – a cleaner environment!

- Assistance with data collection and analysis from the facilitator and students

4.6 TAKING A LIFE CYCLE APPROACH

When trying to make an intervention to improve environmental performance, it is important to think about 'the law of unintended consequences'. Actions that shift environmental burdens need to be avoided. There are three ways in which environmental burdens could be shifted:

- to another place in the supply chain or product life cycle
- to another environmental compartment
- to a later stage in the life cycle of the mine or processing plant.

Burden-shifting can be avoided by using the following approaches:

- Life Cycle Thinking (LCT)
- Life Cycle Management (LCM)
- Life Cycle Engineering (LCE)

LCM and LCE will usually make use of tools, e.g. of a Decision Support Framework (DSF) or of a Life Cycle Assessment (LCA).

In the following sections, each of LCT, LCM, LCE, DSF and LCA will be briefly introduced in the context of the mining industry.

Examples of burden shifting

Don't shift the burden in the life cycle*!*

Most minerals come with unwanted elements that need to be separated and are then usually disposed off with tailings or other solid wastes. To avoid environmental risks at your own disposal site, it might appear possible to 're-design' your product(s). Do not pass problematic minor or minor elements (e.g. cadmium in zinc, or sulphur in coal) to customers, unless a full assessment of the ultimate fate of the problematic elements has been done! (This might require a full → LCA.)

Don't shift the burden to another environmental compartment!

Example 1: Scrubbing a pollutant out of off-gases does not mean that the pollutant has disappeared. It will now be in the liquid or in the solid waste: can it enter the environment from there? Address the problem at source, not at the end of the pipe!

Example 2: Biodiesel might sound like a good idea to reduce fossil CO_2 emissions – but if made from palm oil from new plantations, it might well cause significant biodiversity impacts due to destruction of forests.

Don't shift a problem in time!

Example: Becoming more energy efficient might involve using more toxic materials (e.g. selenium additives in electroplating, or mercury in energy efficient light bulbs). Understand these risks, assess the trade-off (by means of LCA if necessary!) and mitigate risks (e.g. by designing collection and recycling schemes as part of the interventions)!

4.6.1 Life Cycle Thinking

Whenever a change is to be introduced to an operation, it should be a habit to ask about the possible consequences. Even when the proposed change is intended to improve the environmental performance, the three types of burden-shifting questions should be asked:

- Are we shifting the problem to a customer, to a supplier, a neighbour?
- Will this cause a new environmental problem in another receiving environment (air, water or soil)?
- Will this matter come back to bite us in the future?

Include environmental burden shifting questions in Hazop and EIA procedures

Read more in "Why take a Life Cycle Approach" by UNEP, available at http://lcinitiative.unep.fr

4.6.2 Life Cycle Management

Adopting a management approach to product and facility life cycles is a more proactive approach. This can well be integrated with environmental management systems in the following ways.

- Product life cycle – Upstream

- Understand environmental issues in the **supply chain**: get key personnel to interact with suppliers and ask questions.
- Green the supply chain: Work with key suppliers to improve their environmental performance. Insist that they subscribe to a cleaner production philosophy or have an EMS in place.
- Introduce **green procurement**: Add environmental requirements to tender documents or procurement rules.

- Product life cycle – Downstream

  Here it is important to take responsibility for environmental or human health damages that the transportation, further use or ultimate disposal of the products may cause. Keywords are **Product Stewardship** and **Responsible Care**.

- Facility life cycle

  Planning for closure is a core environmental activity in the mining industry. Think how a cleaner production programme could reduce problems at the closure stage.

Read more in "Life Cycle Management: A business guide to sustainability" by UNEP, available at http://Icinitiative.unep.fr

4.6.3 Life Cycle Engineering

Whilst Life Cycle Management aims to improve environmental performance of an existing operation, Life Cycle Engineering aims to design cleaner technology into new projects (or major retrofits). Ask these questions of your design engineer, design team or design house:

- Do you understand the environmental consequences of the currently used technology? Both on site and up and down the life cycle?
- Are others already using cleaner technology?
- Is new technology under development that could make a major improvement? If so, should we learn more about it?
- What tools are you using to assess environmental impacts of proposed designs? (→ LCA, carbon foot-printing)
- Do you care about the environment, and are you capacitated to make difference? (→ continuing professional development, postgraduate qualifications)

4.6.4 Decision Support Frameworks

On what basis does your company make decisions relating to changes in production, new equipment or new projects? All such decisions are likely to have environmental consequences. It is helpful to distinguish between three levels of decisions:

Operational

These include routine technical decisions (e.g. minor capital expenditure for plant replacement or improvement). Most organisations have established strict protocols to enable such decision-making to happen at a decentralised level. It is important that these protocols reflect the various values of the company.

Ensure that your protocol for routine decision-making pays attention is not uni-dimensional (e.g. payback time should not be the only hurdle to take). Environmental concerns should be included, either in the form of objectives, or constraints.

Tactical

The stakes for tactical decisions are higher. Financial risk might be significant, but uncertainty is manageable. Typically, such decisions involve major retrofits or new plant, using proven technology and known business models. It is advisable that projects of this nature go through several development stages and decision-gates. A more sophisticated protocol should exist to guide decision-making at this level, reflecting the full range of values of the company. Multi-criteria decision making (MCDM) tools would normally be employed at this level.

Did you know?

A standard approach to rank alternatives is the weighting and rating method. Each alternative is scored ('rated') against a number of performance measures (e.g. technical, environmental and financial). Each performance measure has a pre-assigned weight (for tactical decisions these weights would normally be fixed and only adjusted from time to time as company values change or new insights emerge). By multiplying the score with the weight, and adding up, a total weighted score is obtained for each alternative.

Strategic

These are the decisions with the highest stakes, not made very frequently, and often involving much uncertainty in addition to significant financial risk. An example might be investing in a new technology at the same time as establishing a new mine or plant. Rewards could be very high (e.g. becoming a technology leader). For this type of decision, it will often be necessary to interrogate the values which the decision-maker(s) place on the developed set of performance criteria. Within the science of multi-criteria decision analysis (MCDA), several techniques exist for establishing decision-maker values.

4.6.5 Life Cycle Assessment

A full environmental life cycle assessment (LCA) may be undertaken to better inform decisions of a strategic nature. An LCA is a scientific study that describes and evaluates the burdens of a process, product or activity over its entire life cycle. The study proceeds through the four stages shown in **Figure 4.3**.

A regular Life Cycle Assessment requires the following:

- A practitioner who is trained in LCA methods.
- Access to LCA software and LCA databases. Commercial providers exist.
- Time.
- An independent peer reviewer (if results are to be communicated externally, this is non-negotiable).

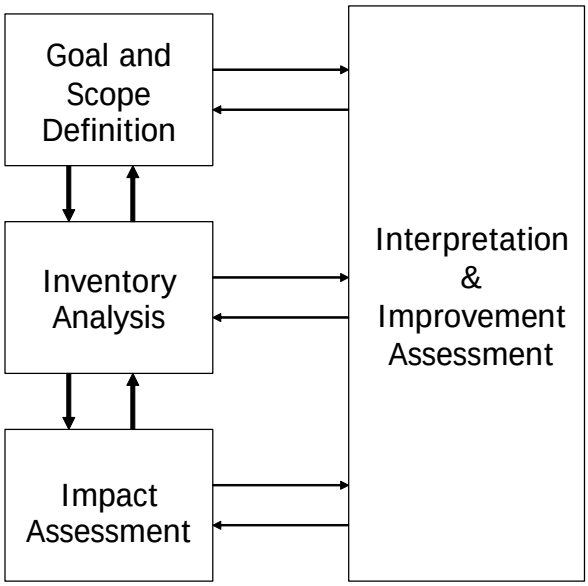


Figure 4.3: Four stages of a life cycle assessment

Did you know?

The process for correctly undertaking an LCA is described the ISO standards 14040-14043. LCA has been formally defined as "an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to effect environmental improvements. The assessment includes the entire life cycle of a product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation and distribution; use, re-use, maintenance; recycling, and disposal"

Source: (SETAC, 1993).

CHAPTER 4: SUMMARY

- √ Assess the applicability of undertaking a scoping audit for your site / department
- √ Determine the true cost of waste for your site
- √ Initiate a monitoring and targeting programme for utility use
- √ Identify ways in which cleaner production aspects can be included in current training programmes
- √ Initiate an awareness raising campaign to reduce waste (of all inputs and outputs)
- √ Investigate the possibility of becoming a member of a cleaner production forum
- √ Identify where the life cycle approach can be used in your business

RECOMMENDED READINGS

Best Practice Programme (1998)

WRC (2006 and 2007)

UK Environment Agency

Environment Australia (1995 (b))

Reddick J (2006)

UNEP web site: http://Icinitiative.unep.fr

5.1 Applicability of Cleaner Production to the Mining Sector

The principles and methodology of implementing cleaner production can be applied within any industrial, commercial or domestic sector, and the mining sector is no exception. Numerous case studies exist to demonstrate the success of cleaner production in reducing environmental impact of mining operations, and resulting in financial savings to the companies involved.

The mining sector faces a number of environmental challenges (see Chapter 2). By viewing these as cleaner production opportunities rather than pressures, a company can aim to make significant financial savings at the same time as improving their environmental performance. Some these *opportunities* include:

- Reducing resource consumption and making financial savings through:
  - Optimising water use to protect limited resources
  - Implementing monitoring and targeting programmes for all utilities
- Implementing an effective environmental management programme
- Reducing greenhouse gas emissions
- Addressing environmental issues such as oil recovery and energy
- Reducing environmental impact and minimising costs with an emphasis on:
  - Rehabilitation
  - acid mine drainage
  - preventative maintenance
  - air quality management
  - effective treatment of waste
  - handling of toxic/harmful chemicals
  - mine closure

While it is recognised that the mining industry cannot completely eliminate its environmental impact, it can achieve cleaner production by continuously implementing physical, managerial, and policy-making changes to minimise its impact until complete reclamation of the mine (***Janisch, 2006***).

5.2 Benefits of Cleaner Production to the Mining Sector

As discussed in previous sections, there are numerous benefits to implementing a cleaner production programme. This section highlights some of those benefits that are of special interest to the mining sector. These include:

- **Compliance with regulations** – by implementing a programme of cleaner production, a company will have better control over all inputs to the process and outputs from the process, including waste. All sources of waste will be identified in the cleaner production process and options sought as to how these can be reduced. By having a clear understanding of what wastes are being produced at each stage of the process, and by optimising all processes to reduce waste source, a company will be able to comply with the required waste discharge regulations.
- **Cost savings** – Numerous case studies have proven that by following a cleaner production programme and identifying opportunities for source reduction, financial savings are possible. In many cases significant cost savings have been achieved for very little investment.

- **Obtaining operating permit** – By incorporating the cleaner production approach into the planning stages, water management plans and rehabilitation plans of the mine, it will assist in complying with the requirements for obtaining an operating permit.
- **Reducing rehabilitation costs –** Cleaner production assists in measuring, monitoring and preventing all emissions and wastes. By incorporating cleaner production principles into operating procedures, the impact of the mining process will be reduced, which will lead to reduced rehabilitation costs.
- **Public image** – contributing in a positive, constructive and pro-active way to your sustainability program, and be seen by your stakeholders as a responsible, positive, constructive and pro-active company.

Case study: Preventing acid mine drainage from the planning stage

The Gregory Coal Mine is an open cut mine located on a lease of 6 500 ha some 60 km north east of Emerald in the Bowen Basin, Central Queensland. The strata just above the main coal seam are pyritic. The pyrite generates acid unless preventative measures are taken as part of the mine operations.
The following operational measures were introduced to reduce acid generation.

- ***Temporary Reduction of Acid Generation from Wastes by Covering with Water***
- ***Permanent Covering of Wastes with Benign Material***
- ***Selective Handling***

Recognition of the potential for acid drainage at Gregory Mine during mine planning also led to the development of a sound, comprehensive water management strategy. Drainage unaffected by mining activities is diverted away from or directly through the mine area so that it is not contaminated by the mine workings. Mine drainage, and particularly mine process water and water which accumulates in mine pits, potentially is contaminated by acid mine drainage. Therefore, this drainage is captured and reticulated back to the mine industrial area where it is available for dust suppression and if required for use in the coal preparation plant.

The early identification of the potential for acid generation from near-coal strata at Gregory Mine has allowed the development and implementation of measures to mitigate the risks of acid formation. The implementation of these plans has allowed mining costs to be controlled, site water consumption to be moderated and site rehabilitation costs to be reduced.

Source: Environment Australia (1997)

5.3 Incorporating Cleaner Production into Existing Environmental Activities

Cleaner Production is based on the sound quality assurance principles of *continuous improvement; doing it right the first time; a need to monitor performance routinely; and implementing corrective action if required (Australian CP Guide).* It is a concept that is easily integrated within management systems such as ISO14000, ISO 9000 and OSHAS 18000 series for environment, quality and health and safety. There is a synergy between cleaner production and health and safety aspects as better control over processes results in less risk to humans. It is also important to include cleaner production aspects at the Environmental Impact Assessment (EIA) stage when planning new projects.

Following a programme of cleaner production also assists in complying with international best practice as promoted by the World Bank, the International Council for Mining and Metals (ICMM), the Global Reporting Initiative and the international declaration on cleaner production. These aspects are highlighted in the following sections.

5.3.1 Cleaner production and environmental management systems

An environmental management system (EMS) that merely satisfies compliance requirements but does not result in reduced risk and improved performance fails its purpose. However, an effective EMS can be a

powerful vehicle for fostering a Cleaner Production culture and moving to best practice. Expanding the existing management systems to include Cleaner Production at every stage is a logical and common sense step. Preventative decisions will have to be made at all stages of the project life cycle from early exploration to mine planning to closure. Down this path, compliance is but an interim goal; the emphasis needs to be on optimising overall efficiency, thus eventually leading to reduced unit cost of production and increased competitiveness (***Environment Australia, 2000***).

An EMS consists of a number of stages; namely (*Australian EMS Guide*):

- Organisational commitment
- Corporate environmental policy
- Environmental impact assessment (EIA)
- Community consultation and involvement
- Objectives and targets
- Environmental management plan
- Documentation and records
- Operational and emergency procedures
- Responsibility and reporting structure
- Training, awareness and competence
- Environmental impact, regulatory and legal compliance, and environmental performance reviews
- Emission and performance monitoring and measurement

Cleaner Production strategies can easily be integrated with the components of an EMS under the headings of organisational commitment; environmental policy; environmental management plan; documentation and records; responsibility and reporting structure; operational and emergency procedures; training and awareness; Environmental impact, compliance, and review audits; and Emission and performance monitoring and measurement (**see Table 5.1**).

If cleaner production principles and methodology are incorporated into an existing EMS, it is more likely to become integrated into day to day operations and be *business as usual*.

The integration of cleaner production into an existing EMS will therefore succeed if:

- Management and staff are committed to the programme;
- Existing procedures, structures, reports and meetings are used as far as possible;
- There is a common understanding of the principles of cleaner production and how they assist with meeting the requirements of the current EMS;
- Any problems and misunderstandings are cleared as soon as possible; and
- Cleaner production principles are incorporated into current EMS training initiatives and awareness campaigns are conducted.

Table 5.1: Cleaner production is an integral part of an environmental management system

Components of an EMS	Contribution (s) to CP
Organisational commitment An successful EMS is based on clear commitment from management	This is the first step in a CP programme. If management does not give clear direction and ensure the involvement of all personnel from the start, then both a cleaner production programme and an EMS will not be successful
Corporate environmental policy An environmental policy clearly states the company's commitment to protecting the environment to its employees and external stakeholders.	The principles of CP are included in an environmental policy statement as it aims to reduce the generation of waste at source through more efficient use of resources and a reduction in emissions to land, water and air.
Objectives and targets A series of targets and long terms objectives need to be set in order to meet the requirements of the EIA process.	CP identifies **what** wastes are being produced **where** and the characteristics of this waste, thus leading to targets for reduction and options for improvement.
Environmental management plan This details the methods and procedures to be used to meet the required targets	The application of CP principles ensures reduced consumption of all input materials (water, energy, raw materials, etc.) and reduced waste generation. Process efficiency will be improved and the company can strive towards best practice operations. CP sets key performance indicators (KPIs) for each production area.
Documentation and records All information should be documented to allow for a paper trail	Reporting and documentation is important for a CP programme so that continuous improvement can be demonstrated
Operational and emergency procedures	A CP audit identifies where the most harmful/toxic waste streams are generated and which should be closely monitored.
Responsibility and reporting structure	The basis of the CP team can be drawn from this responsibility matrix and CP aspects included in existing reporting structures.
Training, awareness and competence A key aspect of an EMS.	Training and awareness are very important aspects of a CP programme. CP principles and methodology can be incorporated into EMS training programmes.
Environmental impact, compliance, and review audits This step identifies the existing and potential impacts on the environment, determines what actions are required to comply with regulatory requirements and company targets.	This forms an integral part of the first stage of a CP audit when all sources of waste are identified and goals for the programme set.
Emission and performance monitoring and measurement Undertaken to ensure procedures are appropriate and that the required environmental outcomes are being achieved.	An important aspect of a CP programme as it ensures that all actions implemented are providing the required outcomes and that continuous improvement is being achieved.

5.3.2 Cleaner production and Environmental Impact Assessments

A document was prepared for the Western Cape Department of Environmental Affairs and Development Planning on how to identify waste minimisation (cleaner production) activities when reviewing EIA applications (Common Ground and deVilliers Brownlie Associates, 2003). All mines have new projects that will require an EIA prior to implementation, and it is important to understand how to incorporate cleaner production / waste minimisation aspects at this planning stage.

An EIA consists of the following stages: screening; scoping; EIA; proposed mitigation, enhancement, management and monitoring; decision-making; and implementation. Waste minimisation/cleaner production aspects should be included in each of these stages. Some examples include:

- **Screening stage**: include sufficient information on key inputs (water, energy, etc.); waste streams (including by-products); proposed waste minimisation and management plans; and the effect on the receiving environment.
- **Scoping stage:** ensure that issues raised by interested and affected parties relating to water, energy or waste are taken into consideration; ensure that all opportunities to reduce waste have been taken into consideration and that the impact of these wastes have been adequately considered.
- **EIA (Report):** ensure that adequate consideration has been given to the long term and cumulative impact of the wastes produced and that the criteria used to evaluate these impacts are sufficient. Where there are likely to be significant impacts related to waste, ensure that consideration of alternatives has been carried out.
- **Mitigation, enhancement, management and monitoring:** ensure that there are sufficient measures in place to mitigate adverse impacts within the legal and policy framework.
- **Decision-making:** informed decisions can only be made if there is sufficient information on the waste production and the impact of all waste streams.

For more detailed information refer to the Common Ground document, Section 3.

5.3.3 The World Bank

The World Bank Group recognizes the potential of countries' mineral sectors to significantly influence regional and national economic and poverty profiles. Their vision is a mining sector that, by attracting private investments, creates a foundation for economic and social well-being and environmental responsibility.

There are a number of guidelines published by the World Bank which support the concept of cleaner production and sustainable development through the promotion of best practice. Some of these include guidelines on health and safety issues (both underground and open cut) and the Pollution Prevention Abatement Handbook (PPAH) which provides sectoral guidelines. The PPAH has been updated with the compilation of new sector guidelines. This information can be downloaded from the World Bank web site (www.worldbank.org/mining), or from the Mining Environment and Development website (www.natural-resources.org/minerals/CD). Of particular interest to the South African mining sector are the guidelines relating to coal mining, base metal and iron ore mining, and the general environmental guidelines.

5.3.4 International Council for Mining and Metals

The International Council for Mining and Metals (ICMM) was formed in October 2001 to represent leading international mining and metals companies. . ICMM is made up of 15 of the largest mining and metal companies, and 24 national mining and global commodities associations. Their vision is a *"viable mining, minerals and metals industry that is widely recognized as essential for modern living and a key contributor to sustainable development."*

ICMM members believe that by demonstrating superior business practices they will gain preferential access to land, capital and markets, thus contributing to high equity values and enabling recruitment of talented

employees. All member companies are committed to the ICMM Sustainable Development Framework and member associations work with ICMM to improve industry performance through developing and sharing good practice.

This is achieved through adhering to the following 10 principles (*www.icmm.com*):

- Implement and maintain ethical business practices and sound systems of corporate governance.
- Integrate sustainable development considerations within the corporate decision-making process.
- Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- Implement risk management strategies based on valid data and sound science.
- Seek continual improvement of our health and safety performance.
- Seek continual improvement of our environmental performance.
- Contribute to conservation of biodiversity and integrated approaches to land use planning.
- Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.
- Contribute to the social, economic and institutional development of the communities in which we operate.
- Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

ICMM Member Companies

- ***Alcoa***
- ***Anglo American***
- ***AngloGold Ashanti***
- ***BHP Billiton***
- ***CVRD***
- ***Freeport-McMoRan Copper & Gold***
- ***Lonmin***
- ***Mitsubishi Materials***
- ***Newmont***
- ***Nippon Mining & Metals***
- ***Rio Tinto***
- ***Sumitomo Metal Mining***
- ***Teck Cominco***
- ***Xstrata***
- ***Zinifex***

Association members within South Africa include the South African Chamber of Mines and the Mining Industry Associations of Southern Africa (MIASA).

Source: www.icmm.com

More details on each of these principles can be found on the ICMM web site **(***www.icmm.org*).

Underpinning the Framework is a commitment to sharing good practice across the industry. This is done through the publication of good practice guidance documents and tools which are developed in close co-operation with members, promotion of ICMM initiatives at conferences and workshops, as well as a good practice website launched in 2004 in partnership with UNCTAD, UNEP and the UK Department for International Development (DFID) ***(****www.goodpracticemining.org*).

In order to demonstrate how these principles are being implemented effectively, ICMM is working with the Global Reporting Initiative to tailor a reporting system for the industry. This is expanded on in **Section 5.3.4.**

5.3.5 Global Reporting Initiative

It is the Global Reporting Initiative's (GRI) mission to provide a trusted and credible framework for sustainability reporting that can be used by organisations of any size, sector, or location. The use of the GRI Guidelines is voluntary and are intended to complement other initiatives to manage economic, environmental, and social performance and related information disclosure. The Guidelines contain general and sector specific content that has been developed in consultation with a wide range of stakeholders. Indicator protocols exist for the following sub-sectors:

- Economic
- Environment
- Human rights
- Labour
- Product responsibility
- Society

The GRI Reporting Framework

Source: www.globalreporting.org

These Protocols provide definitions, compilation guidance, and other information to assist report preparers and to ensure consistency in the interpretation of the Performance Indicators. **Sector Supplements** complement the Guidelines with interpretations and guidance on how to apply the Guidelines in a given sector, and include sector-specific Performance Indicators. A sector supplement for the mining and metals sector has been developed together with the ICMM and can be downloaded from the GRI web site (***www.globalreporting.org***).

5.3.6 International Declaration on Cleaner Production

The Declaration was prepared by UNEP after extensive consultation with diverse interest groups. This declaration is a voluntary but public commitment to the strategy and practice of cleaner production. The Declaration outlines a set of principles, which when implemented will lead to increased awareness, understanding and ultimately, greater demand for Cleaner Production.

The declaration can be signed by government, companies, business associations, academia, non-governmental organizations, and international agencies and organizations. Guidelines for each of these sectors are available to assist in becoming a signatory to the declaration.

The main benefit from signing the declaration is one of improved image as it is a public statement of commitment to cleaner production. This can only be perceived as being a positive step by stakeholders and facilitate the achievement of good public relations.

There are 6 principles covered in the declaration. These are:

- Leadership
- Awareness, education and training
- Integration
- Research and development
- Communication
- Implementation

Goals of the Declaration

- *To encourage support for the adoption of Cleaner Production activities as a prudent economic investment;*
- *To renew and intensify the commitment to Cleaner Production by industrial and*
- *governmental leaders to the extent that they acquire "ownership" and become the local promoters of this strategy;*
- *To promote further international cooperation and technology transfer that will maximise the results and synergies between Cleaner Production initiatives worldwide;*
- *To diversify and broaden the awareness beyond the typical users of Cleaner Production thereby increasing the overall demand;*
- *To spread the awareness of Cleaner Production as a preferred solution to the unsustainable production and consumption of goods and services, in a way that society and community leaders understand exactly how this strategy works and the relevant benefits it provides.*

Source: www.uneptie.org/pc/cp/declaration

There are a number of benefits by implementing these 6 principles such as improved dialogue along the supply chain, long term culture change, innovation, reduced risk and liability, and economic savings. More information can be downloaded from the UNEP web site (*www.uneptie.org/pc/cp/declaration).*

CHAPTER 5: SUMMARY

- √ Understand the benefits of cleaner production to your process
- √ Identify where cleaner production aspects can be incorporated into your current environmental management system
- √ Use the cleaner production methodology as a means of initiating an environmental management system if you don't already have one in place
- √ Understand how international guidelines apply to your process and where you can align your company with these principles
- √ Use the GRI sector supplement to benchmark your performance
- √ Investigate the possibility of signing the UNEP declaration on Cleaner Production

RECOMMENDED READINGS

Environment Australia (2000; 1995(c))

Environment Australia (2002 (b) – Volume 2 on EMS)

Paper by Gavin Hilson and Vishal Nayee (2002)

International Council for Mining and Minerals web site: www.icmm.com

Global Reporting Initiative web site: www.globalreporting.org

Good Practice web site: www.goodpracticemining.com

World Bank web site: www.worldbank.org/mining

UNEP web site: www.uneptie.org/pc/cp/declaration

Common Ground and deVilliers Brownlie Associates (2003)

While it is industry that must ultimately implement cleaner production programmes, it is up to the role of the government to provide an environment that will accelerate the process and encourage industry to initiate their own cleaner production programmes. This Chapter highlights the importance of cleaner production to the mine regulator and the tools that are available to the regulator to promote cleaner production.

6.1 The Importance of Cleaner Production to the Regulator

Why should the regulator promote cleaner production to the mines? Cleaner production is not only beneficial to the mines, but can also assist the mine regulators in the following ways:

- **It will assist in the success of Catchment management programmes**
  Catchment management programmes were initiated by the Department of Water Affairs and Forestry (DWAF) to manage water resources on a regional level. All industries operating within a water catchment area have an impact on the quality of the water in that area. If an industry is following a programme of cleaner production, waste will be minimised and managed at source, thus reducing the impact on the water environment.

- **It will provide an improved relationship between the regulator and the mine**
  Cleaner production provides a win-win situation for the mines and the regulators through providing financial savings and leading to compliance. As both sides realize that they are working towards a common goal, relationships and communication between the mines and the regulator will improve. In the case of a CPF, a regulator has one forum in which to address and communicate with a group of mines about environmental issues such as water, energy and waste (instead of a number of individual mines with each an individual contact person).

  Did you know?

  The concept of a waste minimisation club (or cleaner production forum) was first introduced in the UK by the regulators to assist in the management of a water catchment area. The quality of the river water in the Aire and Calder river basin was being impacted negatively by the industrial activity in the area. The formation of a CPF and the introduction of cleaner production practices within these companies resulted in a vast improvement in the river water quality as well as financial savings to the companies.

- **There will be an improvement in resource management**
  As demonstrated by the available case studies, cleaner production results in a reduction in the use of natural resources such as water and energy (generated from coal and gas) as there is better control over operations and the reuse of resources where possible.

- **There will be improved control over waste discharge**
  Cleaner production results in a reduction the amount of waste generated, and better management (control and treatment) of any waste that is produced, thus reducing the impact on the environment.

6.2 How to identify when Cleaner Production is being implemented

Some of the aspects to look for when assessing if a mine is following a programme of cleaner production include:

- There is a company environmental policy signed by the site manager and made available to all staff (and all staff is aware of the policy).
- Key performance indicators have been established for main utility use (e.g. water, electricity, compressed air, etc.) within each area of the mine and reported on regularly.
- Cleaner production aspects are included in in-house training programme and all staff has a general awareness of the need to save water, raw materials, etc. There are notices / posters, etc. encouraging the minimisation of waste and reducing water and energy use.

- There is a dedicated project champion and team who are responsible for cleaner production issues.
- The management (senior and middle) has a clear understanding of the concepts of cleaner production.
- The source and characteristics of all waste streams has been identified and reduction targets set.
- Monitoring and targeting is carried out on utility use and the company strives for continuous improvement through regular re-assessment of targets.
- The company follows best practice as outlined in the DWAF Best Management Practice Guidelines.

Refer to **Checklist 6 in Appendix** 1 for more detailed indicators of cleaner production within an organisation.

It is also important for regulators to be able to identify when cleaner production aspects have been included in Environmental Impact Assessments (EIA's). A useful document has been prepared for the Department of Environmental Affairs and Development Planning in the Western Cape (Common Ground and deVilliers Brownlie Associates, 2003) which provides guidelines for regulators when reviewing EIA applications. See **Section 5.3.2** for a summary of the main points in this document.

6.3 REGULATORY TOOLS TO ENCOURAGE CLEANER PRODUCTION

Regulators have an important role and a significant opportunity to promote cleaner production practices within the mining companies. A number of activities can be undertaken by the regulator, including:

- Incorporating cleaner production aspects within current and future policy activities;
- Following the National Cleaner Production Strategy strategic goals and objectives which outline the responsibilities of each government department;
- Reviewing the available policy instruments for promoting cleaner production and which have been successfully implementing elsewhere in the world;
- Assisting the mines in implementing a programme of cleaner production

6.3.1 Incorporating cleaner production into policy activities

In order for the regulator to integrate cleaner production aspects into current and future policies, the general attitude and capacity of their relevant department / division to implement and enforce CP measures needs to be assessed.

The following questions need to be asked (***Danida 2003***):

- Does your governmental department / division have a clear **political mandate** to promote cleaner production within local business?
- Are there any **performance target / objectives** in place that provide sufficient **incentive** for you to promote improved resource efficiency and waste minimisation in local businesses?
- Are there any **performance targets / objectives** that you need to meet that act as a **disincentive** against promoting cleaner production practices in companies?
- Have you made provision for waste minimisation measures (and the waste management hierarchy) within the relevant **Integrated Waste Management Plan**?
- Has specific provision been made within the existing (or proposed) **Waste Information Systems** to track the implementation of waste minimisation measures?
- Has your department identified and sought to remove any potentially **conflicting financial incentives** on companies?
- For example does your division rely on effluent charges as a key source of income?

- If companies reduce effluent, would you then increase the per unit charge?
- Are there any incentives for companies to keep reducing effluent and/or waste?
- What efforts have been taken to build the **technical capacity** and knowledge of you and your colleagues on CP? (effective dissemination and training on this booklet should form part of this process)
- Do you have sufficient access to **equipment and/or services** to undertake credible and reliable performance measurements and monitoring?
- Have you considered the various **barriers and drivers** for CP that may operate on companies?

6.3.2 Following National Cleaner Production Strategy Goals and Objectives

The South African National Cleaner Production and Sustainable Consumption Strategy clearly outlines strategic goals and objectives that need to be followed in order to promote cleaner production within South Africa, and lists the responsibilities of each of the national government departments. Within each of the strategic goals, there are a number of objectives that have been identified and methods of achieving these provided.

The five strategic goals are (***NCPC Strategy Version 2, Draft 3: August 2005***):

- **To increase the adoption of Cleaner Production by developing and providing comprehensive and targeted CP information to industry, civil society and government.** This is to be achieved by:

  Increasing awareness in government, industry and civil society

  To foster information networking

  Encourage programmes to develop cross-sectional partnerships

  To provide recognition to organizations implementing cleaner production

  To raise consumer awareness

- **To increase the implementation of Cleaner Production by developing the capacity of staff in government and industry to effect CP interventions.** This is to be achieved by:

  Making use of demonstration projects

  To develop education and training programmes

  To build capacity within all government departments

  To develop a national centre of excellence in cleaner production

  To set targets for continuous improvement

  Signing the *UNEP International Declaration on Cleaner Production.*

- **To increase the use of cleaner technologies across all industry sectors by promoting the development and transfer of environmentally sound technologies.** This is to be achieved by:
  - Encouraging research and development
  - Promoting environmentally sound technologies

- **To increase investments in Cleaner Production by developing financial support schemes and financing mechanisms that encourage CP investments.** This is to be achieved by:

  Include cleaner production aspects in existing financial support schemes

  Encourage the incorporation of cleaner production aspects into financial institutions investment risk assessment procedures

- **To ensure that legislation, policies and regulations support the adoption of Cleaner Production rather than end-of-pipe solutions, and provide for an integrated approach to CP implementation.** This is to be achieved by:
    - Developing an integrated and coordinated policy and regulatory framework
    - Developing economic instruments to support cleaner production
    - To review disincentives to cleaner production such as resource use and waste discharges charges
    - Developing sector-specific programmes to reduce pollution
    - Incorporating cleaner production into permitting and licensing requirements
    - Encouraging manufacturers to design for the environment
    - Including cleaner production aspects into government procurement procedures
    - Pursuing voluntary agreements with industry that set targets for environmental performance

An action plan has been developed to achieve each of these goals.

6.3.3 Policy Instruments for promoting Cleaner Production

There are a number of policy instruments that can be used by government to promote cleaner production, and which have been successfully used in other parts of the world. Many of these instruments have already been included in the National Cleaner Production and Sustainable Consumption Strategy. More detail is provided in this section.

Policy instruments can be broadly divided into:

- Regulatory-based
- Financial and market-based
- Information-based
- Voluntary programmes

Examples of each of these are provided in Table 6.1 (***Danida 2003***) and illustrated in Figure 6.1.

Case study: Cleaner production benefits both industry and regulator

The eThekwini Municipality has introduced a new permitting system that requires a company to demonstrate the implementation of cleaner production within their process. This system has been trialed in the Hammarsdale area of KwaZulu-Natal where companies would qualify for a reduction in their trade effluent tariff if they could prove that they were following a programme of cleaner production. A series of checklists were developed to aid the regulator and the companies were audited by both independent consultants and the pollution officers.

Table 6.1: Examples of policy instruments to promote cleaner production

Policy instrument	Example
Regulatory-based	Set discharge standards such that they encourage the adoption of CP
	Ban the use of substances or technology that cause pollution to encourage the investigation of alternatives
	Include CP in permitting requirements
	Make CP audits a requirement of permitting
Financial or market-based	Impose environmental taxes and charges that encourage the more efficient use of natural resources and limit the discharge of unwanted wastes
	Provide access to grants, loans and subsidies for companies wanting to implement cleaner production options
	Include cleaner production in government procurement policies
Information-based	Disseminate information on best practice
	Promote the formation of cleaner production forums (see Section)
	Promote demonstration projects within various industrial sectors
	Provide public recognition and awards for cleaner production practices
	Make public disclosure of emissions compulsory for all industries
Voluntary agreements	Entering into an Environmental Management Co-operation Agreement
	Link permitting requirements into environmental management systems
	Introduce public voluntary programmes whereby companies disclose their environmental performance in exchange for, e.g. improved public recognition

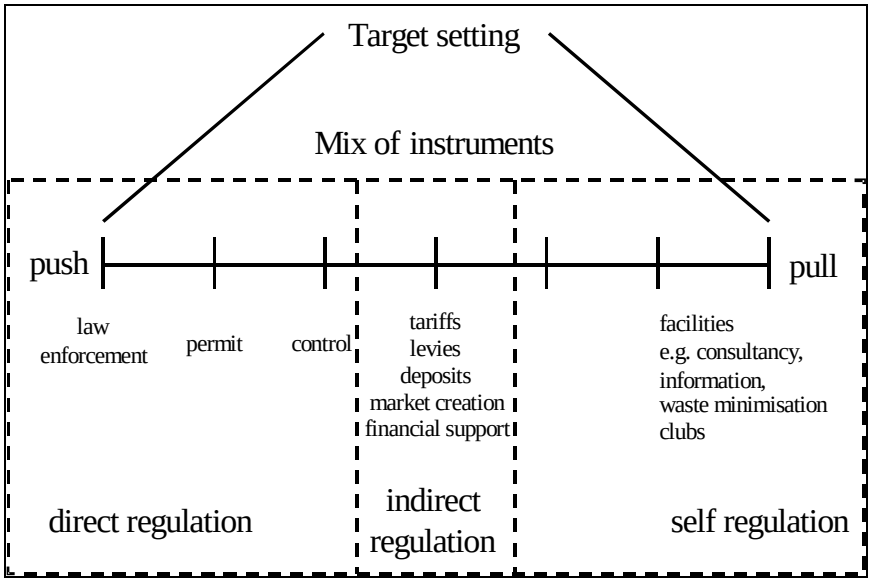


Figure 6.1: Mix of regulatory instruments (*BECO*)

6.3.4 Providing assistance to Mining companies

By understanding the cleaner production process as outlined in Chapter 3, and some of the tools of cleaner production (Chapter 4), you, as the regulator are in a strong position to encourage and motivate the mining houses to implement a programme of cleaner production. The case studies provided throughout this guidance

document, together with the recommended readings and internet references (Appendix), there is sufficient information and proof to demonstrate the benefits of cleaner production.

CHAPTER 6: SUMMARY

- √ Understand how promoting cleaner production to the mining houses will benefit you as a regulator
- √ Identify the needs of your department in order to promote cleaner production
- √ Understand your responsibilities in terms of the National Cleaner Production and Sustainable Consumption Strategy
- √ Identify what policy instruments are available to you in order to encourage cleaner production in the mines
- √ Identify where cleaner production has been incorporated into EIA applications

RECOMMENDED READINGS

Danida (2003)
UNEP (2000)
CEST (1995)
DEAT (2005)
Common Ground and deVilliers Brownlie Associates (2003)

Appendix 1: Checklists / Worksheets to implement a Cleaner Production programme

This Appendix contains some checklists and worksheets to assist you in working through each step of implementing a cleaner production programme. They do not cover every aspect of a cleaner production programme, but aim to provide a basis for developing your own systems.

A1.1 CHECKLISTS

Use the following checklists to assist you in working through each stage of implementing a cleaner production programme. These lists will highlight aspects that need to be undertaken within each step of the programme (Section 3.6). These checklists should be used in conjunction with the worksheets provided in **Section A1.2**.

Checklist 6 is aimed at the regulators to assist them in identifying when a company is following a programme of cleaner production.

Possible cleaner production options have been provided as a separate checklist in **Appendix 3**.

The following checklists are provided:

- Checklist 1: Planning and organisation
- Checklist 2: Assessment stage
- Checklist 3: Identifying cleaner production options
- Checklists 4.1 to 4.4: Undertaking a feasibility assessment
- Checklist 5: Implementation, monitoring and maintaining the programme
- Checklist 6: For the regulator

Checklist 1: Planning and Organisation	Yes	No	n/a
Does your company have an environmental policy statement which incorporates cleaner production aspects?			
Is senior management committed to following a programme of cleaner production			
Has a project champion been selected to drive the cleaner production process?			
Has a project team been identified?			
Have you established goals and objectives for the cleaner production programme?			
Have you identified the possible barriers and ways in which to overcome them?			

Checklist 2: Assessment Stage	Yes	No	n/a
Have you identified major process equipment, operating practices and processes?			
Have you evaluated the quality and quantity of raw material used?			
Have you identified if there is any out-of-spec material produced?			
Have you prepared a process flow diagram for your site?			
Have you undertaken a walk through audit of your site to identify obvious losses and leaks?			
Have you identified all the inputs to and outputs from your site?			
Do you know the amounts and types of wastes generated within your process?			

Checklist 2: Assessment Stage	Yes	No	n/a
Have you identified the true cost of waste?			
Have you collated known monitoring and metering information/data?			
Do you know the current levels of performance in terms of key performance indicators?			
Is the current equipment performing as expecting based on performance guarantees?			
Have you obtained and reviewed copies of any previous reports, audits and operational data?			
Have you completed a waste audit for the site (i.e. identified the sources, types and quantity of waste generated)			
Have you undertaken a water audit?			
Have you undertaken an energy audit?			
Have you identified losses?			
Have you set targets for reduction?			

Checklist 3: Identifying cleaner production options	Yes	No	n/a
Have you reviewed the outcomes of the assessment stage to determine the causes of the waste?			
Have you undertaken brainstorming sessions to identify all possible options for improvement?			
Are all possible solutions recorded for future reference?			
Have you sourced data from literature, case studies and the internet?			
Have you set criteria for the selection of the solution?			

Checklist 4.1: Undertaking a feasibility assessment	Yes	No	n/a
Have you evaluated the technical feasibility of the chosen option(s)?			
Have you undertaken an economic feasibility assessment of the chosen option(s)?			
Have you undertaken an environmental feasibility assessment of the chosen option(s)?			
Are all the options prioritized in terms of urgency, feasibility and cost?			
Have you selected option(s) for implementation?			
Have you put temporary fixes in place until permanent solutions can be implemented (if it is going to take time)?			

Checklist 4.2: Undertaking a technical feasibility assessment	Yes	No	n/a
Have you identified other companies that have implemented similar options?			
Will the option maintain product quality?			
Will there be an adverse effect on production?			
Is the new equipment, materials or procedures compatible with current production and operating procedures and with work flow and production rates?			
Is special expertise required to operate or maintain the new system?			
Have you identified any training requirements for the staff to operate with the new changes?			
Have you identified all the health and safety aspects related to making this change?			
Does this option result in a reduction of waste at source?			

Checklist 4.2: Undertaking a technical feasibility assessment	Yes	No	n/a
Will the change result in a reduction in waste, or will it just convert waste from one form to another (e.g. solid waste to liquid waste)?			
Are materials and parts readily available?			

Checklist 4.3: Undertaking an economic feasibility assessment	Yes	No	n/a
Does this option reduce your raw material costs?			
Does this option reduce your utility costs?			
Does this option reduce material and waste storage costs?			
Have you identified all capital costs associated with implementing this option?			
Have you calculated the running costs associated with implementing this option?			
Are systems in place to record the savings through implementing this option?			
Will this option assist in reducing compliance costs?			
Does this option have an acceptable payback period?			

Checklist 4.4: Undertaking an environmental feasibility assessment	Yes	No	n/a
Will this option assist you in achieving compliance?			
Will this option reduce the toxicity of any waste streams?			
Will this option result in less use of natural resources?			
Will this option reduce the emission of greenhouse gasses?			
Does this option create any other environmental impacts that you need to be aware of and treat?			
Does this option offer the opportunity for on-site reuse?			
Does this option offer the opportunity for off-site recycling?			

Checklist 5: Implementation, monitoring and maintaining the programme	Yes	No	n/a
Have options been implemented in order of priority?			
Has staff been involved in all stages of implementation?			
Has staff been trained in the necessary skills to be able to adjust to the change?			
Does staff understand why the changes have been made?			
Have you identified the training requirements for the various levels of staff?			
Have you initiated an awareness raising campaign?			
Have you monitored the environmental performance of the implemented option(s)?			
Have you monitored the technical performance of the implemented option(s)?			
Are the expected savings being achieved and recorded?			
Are the results reported on to all levels of staff?			
Have you reviewed the goals and objectives of the programme and re-set targets if so required?			
Have you a system in place to continue assessing and identifying cleaner production options in all areas of your site?			

Checklist 6: For the regulator	Yes	No	n/a
Has the company prepared an environmental policy statement that incorporates cleaner production aspects?			
Does the company have an environmental management system?			
Does the manager understand the concept of cleaner production?			
Is there a dedicated cleaner production project champion and project team?			
Has the company undertaken a waste audit of their site?			
Has the company undertaken a water audit of their site?			
Has the company undertaken an energy audit?			
Does the company have key performance indicators set for each utility?			
Does the company report on these key performance indicators regularly?			
Has the company identified targets for reduction?			
Is there a cleaner production training programme in place?			
Are there posters, newsletters, etc. informing all staff of the need to conserve water, energy, etc.?			
Is the company a member of a cleaner production forum?			
Does the company pay attention to housekeeping issues such as leaks, proper storage of goods, etc.?			
Are storm water drain clearly marked and separated to ensure no contamination from process waste water?			

A1.2 WORKSHEETS

This section contains some worksheets that can be used to guide in the various stages of implementing a cleaner production programme. There are numerous sources of similar worksheets in literature that can be adapted to your particular situation and it is recommended that you also make use of this information. This includes (see **Appendix 4** for full reference):

- Australian best practice in mining – sustainability checklists
- Danida cleaner production guide for regulators (Danida, 2003)
- Water Research Commission waste minimisation guide for the textile industry (WRC, 2002)
- Environmental Protection Agency waste minimisation guide (EPA, 1989)
- UNIDO Cleaner Production Tool Kit (UNIDO)

Worksheet 1: Project Team Formulation

Name	Department and contact	Duties		
		Lead	Support	Review

Worksheet 2: Scoping audit Table

Resources and services (Examples)	Quantity Per year	Units	Cost/year Rands	Priority (1=highest)	Scope to save	Scope	Scope
					%	R (min)	R (max)
Raw Materials							
Fist most used					**1 to 5**		
Second most used					**1 to 5**		
Other materials							
Cyanide					**5 to 20**		
Magnetite					**5 to 20**		
Consumables							
Packaging					**10 to 30**		
Energy							
Diesel					**10 to 30**		
Electricity					**5 to 20**		
Gas					**10 to 30**		
Water							
Municipal					**20 to 80**		
Borehole					**20 to 80**		
Effluent							
Disposal					**20 to 80**		
Solid waste disposal							
Hazardous waste					**10 to 50**		
Drum disposal					**10 to 50**		
TOTAL							

Worksheet 3.1: Assessment – Process Flow

(This can be completed for the site as a whole, or for each process area within the site)

INPUTS			PROCESS STEP	OUTPUTS		
Input material	Quantity	Cost		Product/byproduct Waste/emission	Quantity	Cost

Worksheet 3.2: Assessment – Summary of Emissions

(One sheet can be completed for each type of waste – e.g. liquid effluent, solid waste, air emissions, etc.)

Type of emission	Source	Quantity	Is it segregated?	Any treatment in place?	Valuable substances	Main contaminants	Any CP options in place?	Opportunity for CP	Possibility of implementation?

Worksheet 3.3: Assessment – True cost of waste

(This can be completed for the site as a whole, or for a particular section within the mine, or a particular type of waste)

Waste and emission stream	Cost of product loss (per year)	Cost of raw material loss (per year)	Treatment Costs (per year)	Energy losses (per year)	Loss of added value (per year)	Total cost (per year)

Worksheet 3.4: Assessment – Water balance

(a simplified way of recording overall water balance)

Stream no	Water source	Quantity	Unit	Data source/remark

Stream no	Water users	Quantity	Unit	%	Data source/remark

Stream no	Water output	Quantity	Unit	%	Data source/remark
	Wastewater				
	Product				

Worksheet 3.5: Assessment – energy data

Energy type	Quantity/year	Unit	Cost/unit	% of total	Specific consumption	Unit
Electricity						
Oil						
Gas						
Diesel						
Petrol						
TOTAL						

Worksheet 3.6: Assessment -metering information

Utility being measured	Position	Meter no.	Recording period	When calibrated	Responsible person	Where is data stored

Worksheet 4.1: Identification of opportunities – list of options

(Use this worksheet to record the cleaner production options identified by the project team – use a separate sheet for each option)

Cleaner Production option (+ short description)	Identified by	Date

Area of potential saving (s)	Type of saving	Expected capital investment	Expected financial savings
(e.g. water, electricity, product)			

Type of saving = housekeeping, input material, technology, product or recycling

Worksheet 4.2: Identification of Opportunities – evaluation of options

Cleaner Production Option	Evaluation of Criteria				
	Availability	Possibility of implementation	Effect on environment	Feasibility	Financial savings

Give a rating based on the following:

++ very high/very good + high/good +- intermediate – low/bad -- very low/very bad

Worksheet 5: Feasibility Assessment – ranking of options

(use this worksheet to determine the type of feasibility assessment required. Refer to Checklists 4.1 to 4.4 to guide you in undertaking the assessment)

Cleaner Production Option	Evaluation criteria			Need for evaluation		
	Complexity	Expected implementation costs	Expected savings	Technical	Economic	Environmental

Use the following scoring criteria:

++ very complex/very high/very detailed + complex/high/detailed +-reasonable – simple/low/not necessary --very simple/very low

Worksheet 6: Before and after evaluation

(use this worksheet to record the benefits of implementing the specified cleaner production option)

CLEANER PRODUCTION OPTION:

Item (e.g. water, electricity, chemical, etc.)	Unit cost	Consumption before (quantity/year)	Consumption after (quantity/year)	Annual saving (quantity/year)	Financial saving (R/year)

Appendix 2: Checklists for each Role Player

This appendix contains checklists to assist you, as a role player in the mining industry, in identifying your role in promoting and/or implementing cleaner production. Suggested requirements in terms of reporting on cleaner production are also provided.

The following checklists are provided:

- Checklist 1: Head Office
- Checklist 2: Mine Manager
- Checklist 3: Project Champion
- Checklist 4: Environmental Manager
- Checklist 5: Regulator

A2.1 Head Office

Head office will be the most interested in sustainability issues, particularly if the mine belongs to an international group that has committed itself to the goals of the International Council for Mining and Minerals. Checklist 1 provides some suggestions for the type of information that head office may require from the mines.

Checklist 1: Head Office requirements	Yes	Outstanding	N/a
Provide head office with a copy of the environmental policy statement that includes a commitment to cleaner production and sustainability			
Provide quarterly reports on cleaner production performance in terms of specific utility consumption (provides indication of continuous improvement)			
Provide a list of identified cleaner production opportunities together with status of implementation			
Report on financial savings from any interventions			
Report on any environmental benefits from cleaner production; e.g. a reduction in greenhouse gas emissions; reduction in water consumption			

A2.2 Mine Manager

The mine manager holds the responsibility for providing commitment to a programme of cleaner production, thus giving staff within the mine the time and resources to collect and analyse data, and implement feasible options. They in turn have to report to head office on the overall environmental performance of the mine. Checklist 2 provides a list of actions applicable to the mine manager and some ideas on the type of information they should request from the environmental manager and project champion on the cleaner production project.

Checklist 2: Mine Management	Yes	Outstanding	N/a
Provide written commitment to a programme of cleaner production			
Elect a project champion to run the cleaner production programme			
Ensure all staff are informed of your commitment to ensure co-operation with the project team			
Attend cleaner production project team meetings			
Put cleaner production aspects onto the agenda of monthly / quarterly meetings			
Make cleaner production part of each sections performance indicators			
Incorporate cleaner production thinking into current environmental management activities			
Lead by example			
Provide incentives (e.g. recognition) for staff to reduce waste at source			

A2.3 PROJECT CHAMPION

The project champion is the person chosen to head the cleaner production programme and lead the project team in data collection, analysis and identification of opportunities. They are also responsible for reporting to management on the results of the project. Project champions can be chosen from any section within an operation, but generally come from either an environmental or process engineering background.

Checklist 3: Project Champion	Yes	Outstanding	N/a
Elect project team			
Identify barriers to implementing cleaner production and ways in which they can be overcome			
Train project team in data collection techniques			
Provide clear guidelines on the role of each project team member			
Work with the training department to implement awareness raising and training programmes			
Work with the project team to analyse and interpret data			
Lead the brainstorming sessions to identify options for improvement			
Keep a list of all identified cleaner production options even if they are not currently applicable			
Keep clear records of the financial savings and environmental benefits of any cleaner production project			
Report on cleaner production projects to the mine management with emphasis on financial savings			

A2.4 ENVIRONMENTAL MANGER

The environmental manager is responsible for reporting on the environmental performance of the mine and therefore requires information on the environmental benefits of cleaner production. Checklist 4 lists some suggestions as to the type of information that the environmental manager should be requesting from the project team.

Checklist 4: Environmental Manager	Yes	Outstanding	N/a
Identify how cleaner production will assist in complying with regulations / legislation			
Incorporate cleaner production thinking into any current environmental management programme			
Keep records of the environmental benefits (e.g. reduced water use, reduced emissions) of cleaner production to the mine			
Attend project team meetings			

A2.5 REGULATORS

The regulators are in a position to both promote and check on the cleaner production performance of a mine. Checklist 5 provides a list of suggested actions the regulator can undertake to promote cleaner production, as well as a suggested list of information they should request from the mines in order to assess their cleaner production performance.

Checklist 5: Regulator	Yes	Outstanding	N/a
Inform mine of benefits of cleaner production and where they can access information			
Provide case study examples			
Demonstrate how cleaner production can assist in meeting regulatory requirements			
Train inspectors in the methodology of cleaner production			
Encourage mines to participate in Cleaner Production Forums if possible			
Request a copy of the mine environmental policy statement			
Incorporate cleaner production aspects into regulations			
Provide incentives for mines to implement cleaner production options			

Appendix 3: Cleaner Production Checklists

This appendix contains a summary of some cleaner production options relevant to mining operations. The majority of this information has been summarised from the Environment Australia *Best Practice Environmental Management in Mining* Series, and in particular, the **checklist for sustainable mining**. These guides and checklist can be downloaded from the Environment Australia web site **– www.industry.gov.au**. Further information has been taken from the DWAF Best Practice Guidelines for Water Resource Management. These can be downloaded from the DWAF web site at **www.dwaf.gov.za**.

These checklists are by no means exhaustive and you are encouraged to brainstorm solutions within your own organisation, and make use of the references and recommended readings (**Appendix 4**) to assist in the development of cleaner production opportunities.

These following cleaner production checklists are available in this Appendix:

- Checklist 1: general management issues
- Checklist 2: water management
- Checklist 3: energy management
- Checklist 4: dust management
- Checklist 5: noise management
- Checklist 6: chemical management
- Checklist 7: acid mine drainage

CHECKLIST 1: GENERAL MANAGEMENT ISSUES

Cleaner production options related to general management issues cover aspects such as:

- Obtaining management commitment
- Training and awareness
- Measuring and monitoring
- Implementing management plans for all areas (e.g. energy, water, chemical use, etc.) and ensuring all staff are aware of these plans and their role in contributing to their success

Checklist 1: Cleaner Production Option	Yes	No	N/a
Prepare an environmental management policy statement			
Elect a project champion and team			
Set goals and targets for reducing resource use and waste			
Establish a training programme to reduce waste at source			
Undertake regular awareness raising programmes			
Develop key performance indicators for utility use			

CHECKLIST 2: WATER MANAGEMENT ISSUES

The development of an integrated mine water management plan (IMWMP) is essential for any operating mine.

Refer to **Department of Water Affairs and Forestry (2008)** *Best Practice Guideline H1: Integrated Mine Water Management* and **Environment Australia (1999)** *Best Practice Environmental Management in Mining – water management* for more information and case studies on developing an IMWMP. Simple housekeeping options can be found in **Environment Australia (2000)** *Best Practice Environmental Management in Mining – Cleaner Production* as well as **Department of Water Affairs and Forestry (2007**) *Best Practice Guideline H2: Pollution Prevention and Minimisation of Impacts.*

Best management practices in water management for surface and underground mining operations are addressed in **Department of Water Affairs and Forestry (2008)** *Best Practice Guideline A5: Water Management for Surface Mines* and **Department of Water Affairs and Forestry (2008)** *Best Practice Guideline A6: Water Management for Underground Mines.*

Checklist 2: Cleaner Production Option	Yes	No	N/a
Develop a mine water management plan			
Undertake a mine site water balance			
Use contaminated water for dust control rather than clean water			
Optimise water use in all processes			
Implement a monitoring and targeting programme for water use			
Maximize water recycling			
Install water efficient appliances			
Harvest all storm water run-off			
Educate all staff and contractors on water conservation techniques			
Undertake regular water audits			
Segregate storm water from effluent collection pits			
Cover effluent collection pits			
Sweep up or scrape all solid and emulsion spills rather than use wet cleaning			
Stop using bins with narrow openings for storing the emulsion phase as these bins are difficult to clean and require too much water for cleaning			
Drain equipment rather than flush out (blenders, etc.)			
Use mops and sponges with minimum volume of water/and detergents to clean external surfaces of the equipment			
Reduce the water volume used in the cooling bath and re-use the same water for several batches. Use ice if more cooling is required			
Collect the drained cooling bath water as nitrate solution make up water			
Treat oily wastewater from the workshop and power station using an oil-water separator – the separated water can be reused in the operation and oil can be recovered for recycling			
Clarify silted water from the underground operation using silt traps and then reuse			
Thicken tailings water, clarify and then reuse			
Minimise evaporative losses through careful placement of tailings discharge point			
Harvest rain water for irrigation			
Monitor and inspect all bore field pumps and delivery lines regularly			

CHECKLIST 3: ENERGY MANAGEMENT ISSUES

When investigating energy management opportunities, consider:

- Fan loads can account for up to 40% of energy used in underground mines.
- Crushing and milling generally accounts for 50 to 80% of total energy use in a mine
- New blade and tank designs in the separation process can produce up to 50% of energy savings
- Site services can account for 20 to 30% of total energy consumption

Refer to **Environment Australia (2002):** *Best Practice Environmental Management in Mining – Energy Efficiency* for more information and case studies.

Checklist 3: Cleaner Production Option	Yes	No	N/a
General management			
Prepare and energy management strategy for the site			
Implement monitoring and targeting for energy use for the site or per department			
Train staff in energy efficiency / saving procedures			
Undertake a greenhouse gas inventory			
Exploration and drilling stage			
Use less greenhouse intensive vehicle fuels in place of diesel			
Optimise energy and fuel use in camp operations (e.g. cooking and lighting)			
Open cut mining			
Investigate the use of conveyors vs. electric or diesel truck haulage			
Implement the use of in-pit crushing			
Modify blasting to produce smaller ore lumps and reduce crushing energy requirements			
Minimise energy use by vehicles through maintenance and improved fuel efficiency			
Make use of fast-fill methods for refueling and filling water carts			
Underground mining			
Investigate the relative efficiencies and trade offs between electricity, compressed air or diesel for drilling, bogging and transport			
Optimise mine lay out to reduce transport costs and distribution losses			
Improve blasting and caving techniques to reduce ore block size, transport and bogging costs			
Investigate tailings back-fill to avoid or reduce costs of tailings dam construction, pumping and management costs			
Investigate shaft winder vs. decline & truck haul energy costs			
Ventilation and dust extraction			
Review system to match fan capacity and size to demand			
Implement a monitoring system on all fans to optimise usage			
Choose efficient fan designs to reduce inlet/outlet losses			
Re-rate fans if mining levels change significantly			
Review diameter of ventilation drives to reduce pressure drop losses			
Tailings Management			
Locate tailings dams as close as possible to facility			
Investigate gravity flow to reduce pumping requirements			
Where there is surplus water, investigate evaporative or other water loss options to reduce pump back			
Increase tailings density to reduce pumping volumes			

Checklist 3 continued: Cleaner Production Option	Yes	No	N/a
Transport			
Optimise engine management and reduce idling time			
Investigate alternative fuel			
Optimise location of filling stations to reduce travel time			
Make use of fuel additives and conditioners			
Monitor and manage vehicle movement to optimise use			
Maintain optimum tyre pressure			
Design haul gradients to reduce fuel use			
Crushing and milling			
Use the correct primary crusher type			
Optimise crusher size setting			
Optimise screen cloth			
Reduce circulating loads			
Consider early rejection and crushing of scats			
Optimise ball size or feed size			
Monitor load cell to ensure correct charge loads			
Divert excess capacity to other mills			
Separation processes			
review of cell efficiencies to identify potential energy savings in cell agitation, flotation, impeller & drive technology			
replace wedge belt drives with tooth belts			
heat recovery to aid drainage, separation, & control viscosity			
optimise chemical regimes			
oxygen enrichment to reduce air pumping			
use waste heat to dry concentrates, or use solar drying.			
Site services			
Check for leaks in compressed air system			
Review opportunities for using waste compressor heat			
Implement a monitoring and targeting programme over compressed air use			
Install ring main configuration for compressed air			
Standard lighting			
Reduce lighting loads			
Install timers / sensors on lights			
Investigate the use of renewable power			
Use higher efficiency electric motors			
Avoid motor rewinding			
Use solar water heaters			
Use high performance lubricants to reduce friction			

CHECKLIST 4: DUST MANAGEMENT ISSUES

Dust is a generic term used to describe fine particles that are found in the air. These can range in size from a few nanometers to 100 microns. Dust can cause impacts such as:

- Visible plumes and haze
- Staining and soiling of surfaces
- Contamination of water bodies and vegetation
- Health impacts

Refer to **Environment Australia (1998(c)):** *Best Practice Environmental Management in Mining – Dust Control* for further information on dust management and case studies.

Checklist 4: Cleaner Production Option	Yes	No	N/a
Carry out a dust inventory to identify all sources of emissions			
Use an industrial sweeper/vacuum for regular monthly cleaning			
Install manually operated sprays to wet tar-sealed areas			
Tar seal all trafficked areas.			
Cover all loads leaving the site			
Wash vehicles to ensure they leave the site clean			
Install dust extraction filters on crushing and conveying equipment			
Use mist sprays on crushing and conveying equipment			
Enclose conveyors with cover systems			
Monitor impact of dust on health of staff			
Enclose dry separators			
Install ducted extraction system for enclosures			
Install wall and floor partitioning to prevent airborne circulation			

CHECKLIST 5: NOISE MANAGEMENT ISSUES

All forms of mining create noise and vibration from the exploration, construction, and operation stages, through to the decommissioning and rehabilitation.

Refer to **Environment Australia (1998):** *Best Practice Environmental Management in Mining -Noise, Vibration and Air blast Control* for further information and case studies.

Checklist 5: Cleaner Production Option	Yes	No	N/a
Identify all sources of noise and vibration			
Implement a management plan to deal with noise and vibration			
Install acoustic bunding			
Enclose the primary and secondary crushers			
Vibration from blasting			
reduce the maximum instantaneous charge by using delays, reduced hole diameter and /or deck loading			
Implement strict control over spacing & orientation of all blast drill holes			
change the burden & spacing by altering the drill pattern and/or delay layout, or changing hole inclination			
match blast timing to suit local conditions			
use rock breakers or rippers instead of blasting for shallow breaking			
Generation of air blast			
reduce maximum instantaneous discharge			
ensure adequate stemming depth & type			
orientate rock faces away from sensitive receptors			
use a hole spacing & burden which will deliver the minimum explosive force needed to break ore into required size			
where face is already broken, deck load to avoid broken ground or cavities			
eliminate exposed detonator cord and secondary blasting			
blast in favourable weather conditions			
Ensure careful positioning & orientation of blastholes			
blast at set times, or send warnings to sensitive receptors.			
Mine fans			
Balance ventilation fan blades using laser technology			
Sandblast fan blades and coat with an epoxy coating to reduce noise vibration			
Ensure regular cleaning of the noise attenuators			
Enclose fan installation in a building on three sides and line with noise-suppressing material			
Compressor room			
Design and fit a muffler to noisy radiator units			
Fit compressor enclosures with noise-suppressing material to reduce noise at the source			

CHECKLIST 6: CHEMICAL MANAGEMENT

Cyanide is used in the mining sector in the extraction of gold and other metals such as silver, copper and zinc from ores. Cyanide has a potentially harmful impact on both the environment and the health and safety of miners, and therefore all companies must take steps to optimise the use of this chemical.

This checklist summarises some the options available to minimise the use of cyanide. Further information can be found in the publication **Environment Australia (1998)** *Best Practice Environmental Management in Mining – Cyanide Management.*

Checklist 6: Cleaner Production Option	Yes	No	N/a
General management			
Ensure correct storage of all chemicals			
Carry out a chemical balance for the site of any harmful or expensive chemicals			
Monitor and measure chemical consumption such that variations can be spotted immediately and corrective action taken			
Cyanide management			
Prepare a cyanide management strategy for the site			
Train all staff in the risks and effects of cyanide			
Bund all areas containing cyanide to prevent storm water contamination			
Ensure correct clean-up procedures are in place and known to all staff			
Ensure mine closure plan addresses cyanide contamination issues			

CHECKLIST 7: ACID MINE DRAINAGE

Acid mine drainage results from the oxidation of sulphide-rich materials being exposed to the atmosphere during the mining process. The potential for, and the nature of acid mine drainage is site specific and dependent on the type of mineral deposit.

Inadequate control of acid mine drainage can result in significant economic liabilities for both the mine management and the regulator due to the long-term effects on environmental degradation. Therefore it is essential that on-going risk assessment of the potential for acid mine drainage during planning, development, operation and closure of mining operations is undertaken.

More information on acid mine drainage and strategies for reducing this impact can be found in the publication **Environment Australia (1997):** *Best Practice Environmental Management in Mining - Managing Sulphidic Mine Wastes and Acid Drainage.* Checklist 7 summarises some of the actions that can be taken to minimise this problem.

Checklist 7: Cleaner Production Option	Yes	No	N/a
Determine which rock materials have the potential to cause acid mine drainage			
Undertake an acid drainage risk analysis			
Train all staff in correct procedures for managing acid mine drainage			
Implement a monitoring regime for acid drainage			
Include strategies for acid drainage in mine closure plans			
Cover fine wastes and tailings from coal preparation with water and reuse supernatant for coal washing			
Return coarse rejects from coal preparation to the mine pits and cover with spoil from excavation of next mine pit-strip			
Collect and use contaminated water for dust suppression or in coal preparation plant			

Appendix 4: Cleaner Production Reporting Format

It is difficult to provide a set format for reporting on cleaner production as there are many different type of reports that can be prepared depending on (i) what stage the organisation is with regards to implementing cleaner production (i.e. scoping stage; pre-assessment stage; detailed assessment, etc.) and (ii) who the target audience is (i.e. management; stakeholders; government, etc.).

This Appendix contains a format that is requested by the United Nations Industrial Development Organisation (UNIDO) when a company is reporting on cleaner production activities within their organisation. It can be used as a guideline for your report with modifications made depending on who the target audience is and how much information you are happy to release. It provides a suggested table of contents, worksheets that can be used to assist in providing the information, and a section on how the cleaner production programme is to be sustained within an organisation.

ABSTRACT

(not more than 200 words)

This should include:

- short description of the company
- description of the audit focus and reason for the choice
- main CP options identified
- achievements: economic savings and environmental benefits (differentiate between options already implemented and options planned)
- main recommendations for follow-up

TABLE OF CONTENTS

1. INITIAL ENVIRONMENTAL ASSESSMENT

Objective and description:

This chapter shows the first step in this project. It will demonstrate your initial evaluation of your company's environmental performance. This first evaluation gives the reader a first impression of how you see your company before detailed assessment.

Worksheets:

Smiley diagram

Environmental questionnaire – check list

How to use this form?

Print the diagram and two pages of the checklist and distribute them for completion to you management, see description on the form

Expected result:

- first ideas about your strengths and weaknesses in your environmental performance
- awareness for the project
- short report about the evaluation of the diagram and checklist

Smiley Diagram

Define the strengths and weaknesses of areas with environmental impact in order to define the goals for the work of the project team. A first assessment of the current situation is provided by the "initial diagnosis" with the "Smiley diagram". An assessment of the situation with these symbols will probably give better results than grades or percentages.

	☺	😐	☹
Storm Water			
Waste Separation			
Waste Water			
Solid Waste			
Air Quality			
Noise			
Hazardous Materials (including intermediates and by-products)			
Energy			
Environmental Policy			

Environmental questionnaire

CAN YOU ANSWER YES TO THESE QUESTIONS?

If you answer NO to one or more of these questions then you could be missing opportunities to save money, or you could be harming the environment. N/A stands for “not applicable”.

Water quality management	***Raw Material***
Storm water	Do you know the composition of your materials?
Do you know where the storm water drains on your premises are located?	Yes No N/A
Yes No N/A	If a supplier was willing to take your waste for reuse can you guarantee a regular supply?
Do you have any features or procedures in place to prevent storm water pollution?	Yes No N/A
Yes No N/A	Do you have licensed waste transporters to transport:
Are the storm water drains around your business free of pollution? (Litter, sand, metal shavings, etc.)	General production waste? Yes No N/A
	Waste chemicals? Yes No N/A

Yes No N/A

Do you store all equipment, materials and liquids so that spills or leaks could not enter the storm water system?

Yes No N/A

Do you regularly clean up the surface areas around your premises?

Yes No N/A

Do you use a broom instead of a hose to sweep and clean up the surface areas around your premises?

Yes No N/A

Wastewater

Do you have a permit from the local water authority (if needed)?

Yes No N/A

Do floor drains in the work area drain to either a storage tank or direct to the sewer?

Yes No N/A

Do you use a vacuum cleaner (appropriate to the process) to clean up dust and sand?

Yes No N/A

Groundwater

Do you know if your site has groundwater under it?

Yes No N/A

If there is groundwater under your site, do you take precautions to prevent pollutants from entering the groundwater?

Yes No N/A

Liquid wastes? Yes No N/A

Air quality management

Do you take measures to prevent dust from leaving your premises?

Yes No N/A

Do you take measures to prevent fumes and vapour (including odorous emissions) from leaving your premises?

Yes No N/A

Hazardous materials

Do you store all hazardous materials (such as resins, catalysts) in a bunded, covered area that will not allow any spilled or leaked materials to enter the storm water system?

Yes No N/A

Do you have a Dangerous Goods License, if needed?

Yes No N/A

Do you have all the relevant material safety data sheets (MSDS) and keep them in an accessible place?

Yes No N/A

Do you have a spill fighting equipment and written procedures?

Yes No N/A

Noise management

Do you regularly check and carry out maintenance on noisy equipment?

Yes No N/A

If you have had complaints about noise, have you identified the source of the noise and taken steps to reduce its effects?

Yes No N/A

that will be good for you, your staff and your customers.

Management of premises

Have you made any changes to your business for environmental reasons?

Yes No N/A

Do you have an environmental policy or plan?

Yes No N/A

If you answered NO to any of the questions in this checklist you can use the information in this package to develop an environmental improvement program that will be good for you, your staff and customers.

Now that you have completed this checklist and identified the areas where you can make improvements:

• Read through the environmental information sheets.

• Get started on an environmental improvement program

Evaluation of the initial assessment:

Please write a short report about the results and the evaluation of the initial assessment. This report will indicate fist weaknesses of the organization and shall motivate the company to fully commit to the project. It should indicate potential financial savings and increase of productivity.

Max. 1 page

2. COMPANY INFORMATION

Objective:

This chapter gives a brief company profile and contact information. A small site map shall demonstrate the area of assessment and the location of the departments.

Content:

Company table

Site Map

Company plans

How to use this form?

Fill in the empty lines

Company table:

- Company Name	
- Address	
- Phone, Fax	
- e-mail	
- web	
- Trading Since (year)	
- No. of Employees	
- Industrial Process used	
Environmental Team:	
- assigned Environmental Manager and position within the organization	If not assigned please don't fill out
- Team members and positions	- - - - - -
Contact Person: Name Phone Fax and e-mail Position	In case it is not the Env. Manager

Brief Company profile

Please describe your company in a paragraph. Present your products, ownership, certifications, strengths, …

Site Map

Please insert a drawing of you site indicating the location, main buildings and departments. Use existing site maps, if applicable.

3. SUMMARY OF PRODUCTION DATA

Objective:

This chapter gives a detailed description of the production figures on a yearly basis. These figures will help you to understand the main raw material flows and the cost profile of your company. These figures are very important to develop an appropriate indicator set for the company. These indicators can then easily be compared with benchmarks from other companies. The important waste streams of you company will give information about you waste management and your resource efficiency in general. This summary is an overall compilation of the main inputs and outputs of the company independent of the different process steps.

Content:

Document: Worksheet 1

Document: Worksheet 2

Document: Worksheet 3 (incl. energy consumption and costs)

Document: Worksheet 4

How to use this form?

Please fill in the empty lines in the form sheets (1-4) with annual data. Fill in with care and try to give accurate figures from you last fiscal year. Where the data is not available please indicate why – where data are not applicable leave the space free. The data you require you can usually find at different sites – i.e.

Entry:
documents for book-keeping and cost accounting, waybills,
information of suppliers concerning formulae,
in-house data identification concerning packaging
...

Use:
cost centre accounting
measurements at plants and machines
information from staff concerning operating hours and change intervals
bills of materials
formulae
machinery specifications (manuals)
rating plates

Exit:
product lists and formulae,
records of waste and emissions, waybills
settlement of accounts with disposal companies,
information of the waste water association
….

For the definition of the costs for waste please consider the real costs of waste = disposal, lost material, treatment, manipulation, management, etc.

Result:

Production figures and all main waste and emissions in quantity compiled in the worksheets.

WORKSHEET 1

The most important products / services

Company: Name Created by: Page:

No.	Product or service / Intended use	Quantity per year	Measuring unit
1			
2			
3			
4			
5			

Add rows if needed – place cursor at the beginning of this line, go back one position by pressing the "←"-button and press "Enter".

WORKSHEET 2

The most important types of waste and emissions

Company: Created by: Page:

No.	Waste and/or liquid or gaseous emissions	Quantity per year	Measuring unit	Purchase costs	Disposal costs	Total costs
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Add rows if needed – place cursor at the beginning of this line, go back one position by pressing the "←"-button and press "Enter".

WORKSHEET 3

The most important raw and process materials

Company: Created by: Page:

No.	Material	Quantity per year	Measuring unit	Unit costs	Total costs	Use	Percentage in the product
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Add rows if needed – place cursor at the beginning of this line, go back one position by pressing the "←"-button and press "Enter".

WORKSHEET 4

Major toxicological raw and process materials

Company: Created by: Page:

No.	Material	Quantity per year	Measuring unit	Unit cost	Total cost	Use	Percentage in the product
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

4. FLOW CHART AND PROCESS DESCRIPTION

Objective and Description:

What are the most important inputs and outputs in the individual processes? Processes which take place as part of your company's activities can be represented using a detailed process flow chart. Flow chart production is a key step in the assessment and forms the basis for material and energy balances which occur later in the assessment. Process flow charts should pay particular attention to activities, which are often neglected in traditional process flow charts, such as:

- cleaning; materials storage and handling; ancillary operations (cooling, steam and compressed air production); equipment maintenance and repair; materials that are not easily recognisable in output streams (catalysts, lubricants, etc.), waste from shut down, by-products released to the environment as fugitive emissions.

The process flow chart is meant to provide an overview and should thus be accompanied by individual input/output sheets for each unit operation or department (see Document Worksheet 5).

How to use this form?

Please prepare a flow chart of all processes and find a logic way of numbering. Use an extra paper sheet for the original drawing – Size min A3, and copy a small copy of the chart into the report. Add the original in the Annex. Use boxes for the processes and arrows for the flow of materials and energy. Try to differentiate core and auxiliary processes.

For the individual process Input – Output please use the worksheet 5 below. Please do not quantify the processes, just indicate the type of material and energy flows at this stage.

Result:

Flowchart and qualitative description of each process

WORKSHEET 5

Description of the production process in a flow diagram.

WORKSHEET 6

Description of the used technology in the production process

Please give an overview of the used technology

Process: Number	Process Name:	Equipment in Use

5. DETAILED ASSESSMENT PHASE

Objective and Description:

1. First step of this detailed assessment phase is to establish a focus for further work. In an ideal world, all processes and unit operations should be assessed. However time and resource constraints may make it necessary to select the most important aspect or process area.

   It is common for Cleaner Production assessments to focus on those processes that:

   - generate a large quantity of waste and emissions;
   - need a lot of energy and raw material
   - use or produce hazardous chemicals and materials;
   - entail a high financial loss;
   - have numerous obvious Cleaner Production benefits.

2. The next step is the quantitative assessment of the chosen processes. The aim of the detailed assessment phase is to collect data and evaluate the environmental performance and production efficiency of the company. Data collected about management activities can be used to monitor and control overall process efficiency, set targets and calculate monthly or yearly indicators. Data collected about operational activities can be used to evaluate the performance of a specific process.

   It is important to collect data on the quantities of resources consumed and wastes and emissions generated. Data should be represented based on the scale of production: for example: energy consumption per tonne of good casting processed. Collection and evaluation of data will most likely reveal losses. For instance, high electricity consumption outside production time may indicate leaking compressors or mismanaged cupola furnaces.

3. The third step is the Material and Energy Balance Analysis. The purpose of undertaking a balance is to account for the consumption of raw materials and energy that are consumed by the process, and the losses, wastes and emissions resulting from the process. A balance is based on the principle of 'what comes into a plant or process must equal what comes out'. Ideally inputs should equal outputs, but in practice this is rarely the case, and some judgment is required to determine what level of accuracy is acceptable.

   A balance makes it possible to identify and quantify previously unknown losses, wastes or emissions, and provide an indication of their sources and causes. Material and Energy balances are easier, more meaningful and more accurate when they are undertaken for individual unit operation.

   The material and energy balance can also be used to identify the costs associated with inputs, outputs and identified losses. It is often found that presenting these costs to management can result in a speedy implementation of Cleaner Production options.

   While it is not possible to lay down a precise and complete methodology for undertaking a material balance, the following guidelines may be useful:

   Environmental performance indicators for the process can be developed from the material balance data. This is achieved by dividing the quantity of a material input or waste stream by the production over the same period. Performance indicators may be used to identify over-consumption of resources or excessive waste generation by comparing them with those of other companies or figures quoted in the literature. They also help the company track its performance towards its environmental targets.

How to use this form?

Step 1: In determining what process data to collect, use the input/output worksheets 5, described previously and the worksheet 6 as a guide. Worksheet 6 will have instructions on the sheet. The steps evaluated as significant will then be listed according to your priority in Worksheet 7.

Step 2: Collect quantitative data. Most data will already be available within the company recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and the production data. Where information is

not available, estimates or direct measurements will be required. Where the data is not available please indicate why.

Step 3: For the material and energy balance for the chosen processes please fill in the collected data in worksheet 8 and develop a material and energy balance.

Result:

The result of this detailed assessment will be the basis for option generation.

6. REGISTER OF ENVIRONMENTAL ASPECTS AND EVALUATION OF SIGNIFICANT PROCESSES

This overview helps the consultant to define the processes which are important for further investigation throughout a material and energy balance analysis.

WORKSHEET 7:

Red is a significant process

Orange: process needs to be observed

Green: Process need to be further investigated

Impacts: 1 is significant – 2 is minor significant – 3 not significant

The final ranking is your suggestion and is your decision

Example:

Department: Furnace Process: Name and Number Melting of raw material in the cupola Responsibilities: Foreman Evaluation Result: significance red										
Activity Product	Aspect - normal - abnormal Operation	Environmental and Economical Impacts					overall signifi-cance traffic light			Action
		Nature	Human	Raw Material	Energy	Legal compliance				
Write the process step	In normal use Accident or break down	Impacts to flora, fauna…	health and safety …	Raw material and waste	Loss of heat, energy	Danger of non compliance	RED	ORANGE	GREEN	further assessment observation no action
Charging the furnace	- dust generation - wrong dispensing .. …	1	1	1	1	3				Material Balance
Melting	- hot air emission - wrong operation … ….	1	2	1	1	3				Energy Balance

Department: Process: Responsibilities: Evaluation Result: significance red										
Activity Product	Aspect - normal - abnormal Operation	Environmental and Economical Impacts					overall signifi-cance traffic light			Action
		Nature	Human	Raw Material	Energy	Legal compliance				

7. SELECTION OF AUDIT FOCUS

WORKSHEET 8

In the table below the areas initially identified as having opportunities for implementation of CP within the production process concerned can be given. In the second column ('CP Focus') the specific part(s) on which the CP audit should concentrate should be indicated. Finally, the implementation priority and remarks about the prioritization can be stipulated.

Identified (sub-)processes with CP opportunities		CP Focus	Priority	Remarks
1.		(F1)		
2.		(F2)		
3.		(F3)		
4.		(F4)		
5.		(F5)		
6.		(F6)		
7.		(F7)		
8.		(F8)		
9.		(F9)		
10.		(F10)		

WORKSHEET 9:

Mass and energy balances for option finding

Benchmarks: Name if known Process: Name and Number							
Input		Source of information	Output			Source of information	
Name:	Quantity	Value		Quantity	Balance	Value	Loss
raw material 1:			product 1:				
raw material 2:			product 2:				
raw material 3:			product 3:				
water:			non-product 1:				
energy:			non-product 2:				
others 1:			non-product 3:				
others 2:			waste water:				
others 3:			energy loss:				

8. CLEANER PRODUCTION OPTIONS: GENERATION AND IMPLEMENTATION

Objective:

Identifying Cleaner Production opportunities depends on the knowledge and creativity of the project team members and company staff, much of which comes from their experience. Many Cleaner Production solutions are arrived at by carefully analysing the cause of a problem.

Another way of identifying Cleaner Production opportunities is to hold a 'brainstorming' session, where people from different parts of the organisation meet to discuss solutions to specific problems in an open and non-threatening environment.

Some other sources of help from outside the organisation could be:

- this guide and the UNIDO Toolkit textbooks
- external industry consultants;
- industry associations;
- equipment suppliers;
- literature and electronic databases
- UNIDO

Once a number of Cleaner Production opportunities have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation.
The objective of the evaluation and feasibility study phase is to evaluate the proposed Cleaner Production opportunities and to select those suitable for implementation.

Technical evaluation

The potential impacts on products, production processes and safety from the proposed changes need to be evaluated before complex and costly projects can be decided upon. In addition, laboratory testing or trial runs may be required when options significantly change existing practices. A technical evaluation will determine whether the opportunity requires staff changes or additional training or maintenance.

Economic evaluation

The objective of this step is to evaluate the cost effectiveness of the Cleaner Production opportunities. Economic viability is often the key parameter that determines whether or not an opportunity will be implemented.

When performing the economic evaluation, costs of the change are weighed against the savings that may result. Costs can be broken into capital investments and operating costs. A standard measures used to evaluate the economic feasibility of a project is the “payback period”.

Capital investment is the sum of the fixed capital costs of design, equipment purchase, installation and commissioning, costs of working capital, licenses, training, and financing. Operating costs, if different to existing conditions will need to be calculated. It may be that operating costs reduce as a result of the change, in which case, these should be accounted for in the evaluation as an ongoing saving.

Environmental evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the option. In many cases the environmental advantages are obvious: a net reduction in toxicity and/or quantity of wastes or emissions. In other cases it may be necessary to evaluate whether, for example, an increase in electricity consumption would outweigh the environmental advantages of reducing the consumption of materials.

For a good environmental evaluation, the following information is needed:

• changes in amount and toxicity of wastes or emissions;

• changes in energy consumption;

• changes in material consumption;

• changes in degradability of the wastes or emissions;

• changes in the extent to which renewable raw materials are used;

• changes in the reusability of waste streams and emissions;

• changes in the environmental impacts of the product.

In many cases it will be impossible to collect all the data necessary for a good environmental evaluation. In such cases a qualified assessment will have to be made, on the basis of the existing information.

Given the wide range of environmental issues, it will probably be necessary to prioritise those issues of greatest concern.

How to use this form?

The worksheet 10 is a compilation of the identified CP options per area of focus. Fill in the option and try to evaluate the feasibility of the option, with the help of the expert team as accurate as possible.

The opportunities selected during the assessment phase should all be evaluated according to their technical, economic and environmental merit. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects. For some options, it may be necessary to collect considerably more information. An important source of this information may be employees affected by the implementation.

WORKSHEET 10

CP options generated per identified Focus of Audit. Per CP Focus give the CP Options according to the table below. The number in the upper left corner of the table corresponds with the selected CP Focus (see 5, 'Selection of audit focus').

F1	If table is not complete for your purposes kindly add new components but keep lay out settings	Only fill out Pos (= positive, yes), Neut (= neutral, don't know), Neg (= negative, no) or n.a. (= not applicable, not available)						
Description of CP Option[1]		Directly Implemented[2]	Technical Feasibility	Economic Viability	Environmental Evaluation	Implementation Decision	Investment (R)	Savings (R)
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								
Add rows if needed – place cursor at the beginning of this line, go back one position by pressing the "←"-button and press "Enter".								

[1] Try to describe exactly, what should be changed, for example: change of raw material by using recycled material, change manual control of fuel feed for boiler to automatic control consisting of preventative maintenance, etc.

[2] Without further assessment

For every focus a table can be added by copying the table above.

9. IMPLEMENTATION AND CONTINUATION

Objective:

The objective of the last phase of the assessment is to ensure that the selected options are implemented, and that the resulting reductions in resource consumption and waste generation are monitored continuously.

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects.

However, special attention should be paid to the need for training staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

How to use this form:

Preparation of an action plan: To ensure implementation of the selected options, an action plan should be developed, detailing:

- activities to be carried out;
- resource requirements (finance and manpower);
- the persons responsible for undertaking those activities;
- a time frame for completion with intermediate milestones.

Worksheet 11 gives an example for an action plan:

It is very important to evaluate the effectiveness of the implemented Cleaner Production options. Typical indicators for improved performance are:

- reduction in wastes and emissions per unit of production;
- reduction in resource consumption (including energy) per unit of production;
- improvement in profitability.

There should be periodic monitoring to determine whether positive changes are occurring and whether the company is progressing toward its targets. For monitoring use worksheet 12.

WORKSHEET 11: ACTION PLAN

Give a detailed action plan table for every CP Focus separately (F1, F2, etc.).

F1	Task	Resources needed (if any)	Responsible person	Date due	Date accomplished
1.					
2.					
3.					
4.					
5.					

WORKSHEET 12: MONITORING

Give an overview of the achievements for every CP Focus separately (F1, F2. etc). If not, consider the full production process concerned with total production figures. The figures should include the savings and benefits achieved for all options already or partly implemented. Please also add a separate table showing the benefits expected from the CP options that are planned for the next year but not yet implemented.

Kindly consider shifts of waste load from one flow to another (e.g. from waste water to solid waste/sludge)

F1	If table is not complete for your purposes kindly add new components but keep lay out settings	Quantity or %	Explanation (if necessary)
Increased production	type of product		
Savings - use '+' to indicate %-increase - use '-' to indicate %-decrease	raw material 1		
	raw material 2		
	etc.		
	water consumption		
	energy		
	time		
Environmental impact - use '+' to indicate %-increase - use '-' to indicate %-decrease	non-product output 1		
	non-product output 2		
	etc.		
	waste water discharge		
	- BOD		
	- COD		
	- etc.		
	gas emissions		
	- NO_x		
	- CO_2		
	- SO_2		
	- CFC		
	- ODS		
	- VOGs		
	- Global warmers		
	- etc.		

Note: if data are not available or the component is not applicable, do not fill out a blank but kindly delete component or fill out n.a. For every focus a table can be added by copying the table above.

10. SUSTAIN CLEANER PRODUCTION ACTIVITIES

Objective:

If Cleaner Production is to take root and progress in an organisation, it is imperative that the project team does not lose momentum after it has implemented a few Cleaner Production options. Sustained Cleaner Production is best achieved when it becomes part of the management culture through a formal company environmental management system or a total environmental quality management approach.

An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production.

If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.
Regardless of which approach is undertaken, Cleaner Production assessment and environmental management systems are compatible. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework, but it needs a technical focus as well.

Like the Cleaner Production assessment, an environmental management system should be assessed and evaluated on an ongoing basis and improvements made as required. While the specific needs and circumstances of individual companies and countries will influence the nature of the system, every environmental management system should be consistent with and complementary to a company's business plan.

How to use this form:

Write in this section how you a planning to sustain your project. Compile a report to the management for reviewing with discussions about lessons learned, savings archived and achievable, recommendations (from the CP expert to the management) and the next steps of the projects. Outline the continuous improvement process and the possibility for the future.

11. ENVIRONMENTAL POLICY

The Policy should be defined after assessing the environmental impacts of the organization. The policy should outline the commitment of the management to reduce its negative environmental impacts. The policy should also state how the company continuously improves their environmental performance. The policy must be signed by the management of the organization.

(If possible prepare the policy in accordance to the regulation of ISO 14001)

The environmental shall draft an environmental policy during the project period and hand it to the management for reviewing.

12. ANNEX

Containing all relevant additional data.

Appendix 5: By-Products / Wastes from Mining

This appendix lists some of the main by-products / waste produced in mining and potential uses for these wastes.

By-product / waste	Source	Potential use
Slag	metallurgical processes (smelting)	Gravel; cement additive; smaller amounts finely ground for sandblasting
Waste rock	Excavation – development of a shaft through a number of kilometers of rock which does not contain any valuable minerals	Building aggregate (roads, bricks, etc.)
Top soil	Excavation	Rehabilitation
Tailings	Processing	Typically no good and contaminated with small amounts of chemicals, but could be used as additive in brick making in some cases.
Coal wastes (fines and coarse)	Mining	Can be reprocessed at a later date to extract a bit more carbonaceous material. Can be used for brick making.
Acid gold tailings dams	Gold mining	Uranium extraction

Appendix 6: Information Sources

A6.1 References in Document

This section provides the detail on any documents referenced in the Guidance Document, both within the text and within the recommended readings boxes at the end of each chapter.

BECO: Barriers and how to overcome them; Internal document

BECO: True cost of waste exercise; Internal document

Best Practice Programme (1998): *Good Practice Guide 112 – Monitoring and Targeting in Large Companies*; Energy Efficiency Enquiry Bureau, Oxfordshire, UK

CEST (1995): *Waste Minimisation – A route to profit and cleaner production; Final Report on the Aire and Calder Project;* Centre for Exploitation of Science and Technology, London, UK

Common Ground and deVilliers Brownlie Associates (2003): *A waste minimisation guideline document for environmental impact assessment (EIA) reviews.* Department of Environmental Affairs and Development Planning, Western Cape.

Danida (2003): *Cleaner Production – A guide for regulators*

DEAT (2005): *South African National Cleaner Production and Sustainable Consumption Strategy*, Version 2, Draft 3, August 2005; Pretoria, South Africa

Department of Water Affairs and Forestry (2007): *Best Practice Guideline H2: Pollution Prevention and Minimisation of Impacts.*

Department of Water Affairs and Forestry (2006): *Best Practice Guideline: A1.1 Small-Scale Mining – User Format*

Department: Water Affairs and Forestry (2007): *Best Practice Guideline A2: Water Management For Mine Residue Deposits*

Department of Water Affairs and Forestry (2007): *Best Practice Guideline A3: Water Management in Hydrometallurgical Plants.*

Department of Water Affairs and Forestry (2007): *Best Practice Guideline A3: Water Management in Hydrometallurgical Plants.*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline A5: Water Management for Surface Mines*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline A6: Water Management for Underground Mines.*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline A6: Water Management for Underground Mines.*

Department of Water Affairs and Forestry (2006): Best Practice Guideline G2: Water and Salt Balances.

Department of Water Affairs and Forestry (2006): *Best Practice Guideline G3. Water Monitoring Systems.*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline G4: Impact Prediction.*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline G5: Water Management Aspects for Mine Closure.*

Department of Water Affairs and Forestry (2008): *Best Practice Guideline G5: Water Management Aspects for Mine Closure.*

Department of Water Affairs and Forestry (2007): Best Practice Guideline H2: Pollution Prevention and Minimisation of Impacts

Department of Water Affairs and Forestry (2006): *Best Practice Guideline H3: Water Reuse and Reclamation*

Department of Water Affairs and Forestry (2007): *Best Practice Guideline H4: Water Treatment.*

Environment Australia (1998(a)): *Best Practice Environmental Management in Mining -Noise, Vibration and Air blast Control*

Environment Australia (1997): *Best Practice Environmental Management in Mining -Managing Sulphidic Mine Wastes and Acid Drainage*

Environment Australia (1998(b)): *Best Practice Environmental Management in Mining – Cyanide Management*

Environment Australia (1998(c)): *Best Practice Environmental Management in Mining – Dust Control*

Environment Australia (1995 (a)): *Best Practice Environmental Management in Mining –Mine Planning for Environment Protection*

Environment Australia (1995 (b)): *Best Practice Environmental Management in Mining – Planning a Workforce Environmental Awareness Training Programme*

Environment Australia (1995 (c)): *Best Practice Environmental Management in Mining – Environmental Management Systems*

Environment Australia (2000): *Best Practice Environmental Management in Mining – Cleaner Production*

Environment Australia (2002 (a)): *Best Practice Environmental Management in Mining – Energy Efficiency*

Environment Australia (2002 (b)): *Best Practice Environmental Management in Mining – Training package (volumes 1, 2 and 3)*

Environment Australia (1999) *Best Practice Environmental Management in Mining – water management*

Enviros Consulting (1999): *Waste Minimisation Training Modules*

Hilson G and Nayee V (2002): *Environmental management system implementation in the mining industry: a key to achieving cleaner production*; International Journal of Mineral Processing (64) pp 19-41

Hilson G (2000): *Barriers to Implementing Cleaner Technologies and Cleaner Production Practices In The Mining Industry: A Case Study Of The Americas*; Minerals Engineering, Vol. 13, No. 7, pp. 699-717, 2000

Jane Reddick (2006): *An Investigation Of Cleaner Production Opportunities In The South African Coal Mining Industry*; University of Cape Town, Msc Thesis

UNEP (1990)

UNEP (1998): *Cleaner Production in Pulp and Paper Mills: A Training Resource Package*; UNEP Industry and the Environment, France.

UNEP (1996): *Cleaner Production: A Training Resource Package*; UNEP Industry and the Environment, France.

UNEP (2000): *Government Strategies and Policies for Cleaner Production; UNEP division of Technology,* Industry and Economics; Paris, France

UK Environment Agency: *Waste Minimisation – getting staff involved*

WRC (2006): *Applicability of Waste Minimisation Clubs in South Africa – Results from Pilot Studies;* Barclay SJ and Buckley CA; Water Research Commission, TT 161/05; Pretoria, South Africa

WRC (2007): *Facilitators' Manual for Establishing and Running Waste Minimisation Clubs in South Africa*; Barclay SJ and Buckley CA; Water Research Commission; To be published

A6.2 RECOMMENDED READINGS

This section lists other sources of information on cleaner production, both in general and specifically for the mining sector, that has not been referred to in the text. An internet reference is provided where you can either download or order the document.

These recommended readings are divided into the following tables:

- Cleaner production in the mining sector
- Generic cleaner production / waste minimisation training material
- Generic cleaner production / waste minimisation guides
- Energy aspects
- Cleaner production forums / waste minimisation clubs

Cleaner Production in the Mining Sector

Title	Source	Comments
Best Management Practice Guidelines for Water Resource Protection in the South African Mining Industry	Department of Water Affairs and Forestry www.dwaf.gov.za	A series of guides to assist you in applying best management practices to all aspects of water use and disposal.
Best Practice Environmental Management In mining Series	Environment Australia www.industry.gov.au or www.natural-resources.org/minerals/cd/index.htm (and link to Environment Australia)	A series of guides to assist you in dealing with various aspects related to mining (some of which have been referenced in the text). All can be downloaded from this site.
Best Practice Environmental Management In mining Series – sustainability checklist	Environment Australia www.industry.gov.au	A checklist that is to be used alongside each of the guides above.
Mining and the Environment: Case Studies From The Americas	International Development Research Centre www.idrc.ca/en	A book that can be downloaded from the site free of charge.
Technological options for waste minimisation in the mining industry **Catherine Driussi, Janis Jansz**	Journal of Cleaner Production (2005)	www.elsevier.com/locate/jclepro
Pollution minimisation practices in the Australian mining and mineral processing industries **Catherine Driussi, Janis Jansz**	Journal of Cleaner Production (2005)	www.elsevier.com/locate/jclepro
Pollution prevention and cleaner production in the mining industry: an analysis of current issues **Gavin Hilson**	Journal of Cleaner Production 8 (2000) 119-126	www.elsevier.com/locate/jclepro
Integrating the environmental and sustainable development agendas into minerals education **Rene Van Berkel**	Journal of Cleaner Production 8 (2000) 413-423	www.elsevier.com/locate/jclepro

Generic cleaner production / waste minimisation training material

Title	Source	Comments
How to prevent waste and emissions in your company – a self-help guide	Clean Technology Centre; Training and Awareness Raising Products www.ctc-cork.ie	
GG106: Cutting costs by reducing waste – running a workshop to stimulate action	Envirowise www.envirowise.gov.uk	A good source of material for a basic introduction to cleaner production
GG174: Profiting from practical waste minimisation – running a workshop to maintain the momentum	Envirowise www.envirowise.gov.uk	Useful hints for how to keep a cleaner production programme going
GG229: Profiting from reducing water use – running a workshop to stimulate action	Envirowise www.envirowise.gov.uk	Some good exercises for demonstrating process mapping and mass balancing
Cleaner Production: A training resource package	UNEP IE, March 1996 www.unepie.org	Can download off the site or order in hard copy
Principles of pollution prevention and cleaner production: an international training course (Trainers and participants manuals)	US EPA – Office of International Activities, 1999 www.epa.gov	Available to download off the web site

Generic cleaner production / waste minimisation guides

Title	Source	Comments
GG296: Cleaner production design: a practical approach	Envirowise www.envirowise.gov.uk	
GG125: Waste minimisation pays – five reasons for reducing waste	Envirowise www.envirowise.gov.uk	
GG067: Water saving devices	Envirowise www.envirowise.gov.uk	Practical information on devices that can be used to save water
ET225: Waste account	Envirowise www.envirowise.gov.uk	
ET219: Waste mapping – your route to more profit	Envirowise www.envirowise.gov.uk	
ET030: Finding hidden profit – 200 tips for reducing waste	Envirowise www.envirowise.gov.uk	Some practical waste minimisation ideas
GG38C: Cutting costs by reducing waste: a self-help guide for growing businesses	Envirowise www.envirowise.gov.uk	
GG25: Saving money through waste minimisation – raw material use	Envirowise www.envirowise.gov.uk	
GG26: Saving money through waste minimisation – reducing water use	Envirowise www.envirowise.gov.uk	
Money for nothing and your waste tips for free	UK Environment Agency www.environment-agency.gov.uk	Booklet that accompanies a video on waste minimisation.
Waste minimisation: an environmental good practice guide for industry	UK Environment Agency www.environment-agency.gov.uk	
Waste minimisation – getting staff involved	UJ Environment Agency www.environment-agency.gov.uk	An excellent source of information on how to raise awareness in an organization.
Tool: Waste minimisation interactive tool	Envirowise www.envirowise.gov.uk	A computer programme that assists in monitoring progress in waste minimisation
Guide to industrial assessment for pollution prevention and energy efficiency	US EPA, EPA/625/R-99/003 June 2001, www.usepa.com	To order

Title	Source	Comments
Audit and reduction manual for industrial emissions and waste	UNEP and UNIDO Technical report No.7, 1991	To order
Waste minimisation opportunity assessment manual	US EPA, 1998 www.usepa.com	The first self-assessment sheets developed

Energy Aspects

Title	Source	Comments
GG18: reducing energy consumption costs by steam metering	Energy Efficiency Best Practice Programme www.carbontrust.co.uk/energy	Available to order from the web site
GG30: Energy efficient operation of industrial boiler plant		
GG126: Compressing air costs		
GG84: Managing and motivating staff to save energy		
GG85: Energy management training		

Cleaner Production Forums / Waste Minimisation Clubs

Title	Source	Comments
GG122: Waste Minimisation Clubs: Setting them up for success	Envirowise www.envirowise.gov.uk	This site also has links to CPF throughout the UK
Less is more: Final report for the East of Scotland Waste Minimisation Project	Not known.	Can link through the Envirowise web site
Sustainable Business in Action	Sabina www.sabina.co.uk	Information on the Welsh cleaner production demonstration project

A6.3 USEFUL INTERNET SITES

The following table provides a list of internet sites that contain useful information related to both the mining sector and cleaner production.

Title	Source	Comments
Chamber of Mines SA	www.bullion.co.za	Information on the mining sector in South Africa
Department of Minerals and Energy	www.dme.gov.za	Information on legislation, etc. related to mining in South Africa
Coaltech	www.coaltech.csir.co.za	
National Cleaner Production Centre	www.ncpcsa.co.za	Information on CP projects within South Africa (including CPF)
Mining, Environment and Development	www.natural-resources.org/minerals/cd/index.htm	Excellent source of information relating to the mining sector that has been published by UNIDO, UNEP, OECD, Environment Australia, etc.
Envirowise	www.envirowise.gov.uk	Excellent source of guides, case studies, fact sheets, etc. for various sectors.
Energy Efficiency Best Practice Programme – the Carbon Trust	www.carbontrust.co.uk/energy	Download the publication list and order relevant guidelines. Some guides are available for download on the site
Action Energy	www.actionenergy.org.uk	A number of useful publications on energy use to download.
UK Environment Agency	www.environment-agency.gov.uk	Publications for download on the web site.
Green Profit	www.greenprofit.net	Case studies for a number of sectors
World Bank	www.worldbank.org	Links to sources of information on waste minimisation and cleaner production
United Nations Environment Programme (UNEP)	www.unep.org Access the library to download documents on cleaner production in various sectors and also on how to set up a cleaner production centre	Links to all UNEP Cleaner production centers worldwide. Each centre has information and training on cleaner production that can be accessed.
Canadian Centre for Pollution Prevention	www.c2p2online.com	Useful publications – do a search for mining
Centre of Excellence in Cleaner Production	htpp://cleanerproduction,curtin.edu.au	Useful information on CP
Target Zero	www.ccc.govt.nz/targetzero	Publications, case studies, guides, etc. to download.
Uranium Information Centre	www.uic.com.au	

Appendix 7: Useful Contacts

This appendix contains a list of organizations that will assist in providing further information / advice / training in cleaner production and related issues.

A7.1 GOVERNMENT DEPARTMENTS

The following table lists the relevant contact people within the National Government.

Department	Contact Person	Contact Details
Department of Minerals and Energy	**LeBeau LaBuschagne** Acting Deputy Director: Environment Directorate: Mine Environmental Policy	Tel: +27 (0) 12 317 8300 Fax: +27 (0) 12 320 6786 Cell: 082 45 36 760 lebeau.labuschagne@dme.gov.za
	Head office	Tel: + 27 (0) 12 317 8000 Fax: +27 (0) 12 322 3416 Private Bag X59 Mineralia Centre 234 Visagie Street Pretoria 0001
Department of Environment Affairs and Tourism	**Ms Tebatso Matlala** Deputy Director: Industry Support **Zanele Mvusi** Chief Director: Pollution and Waste	Tel: (012) 310 3388 Fax: (012) 322 2309 TMatlala@deat.gov.za ZMvusi@deat.gov.za
	Call Centre	086 111 2468 callcentre@deat.gov.za
		315 Pretorius street cnr Pretorius & van der Walt Streets Fedsure Forum Building North Tower Private Bag X447 Pretoria 0001
Department of Water Affairs and Forestry	**Paul Herbst**	Tel: + 27 (0) 12 392 1360 Fax: + 27 (0) 12 392 1453 Cell: 082 804 3002 herbstp@dwaf.gov.za
	Letladi Maisela Assistant Director: Resource Protection and Waste: Mines	Tel: +27 (0) 12 336 7235 Fax: +27 (0) 12 323 0321 Cell: 082 908 2776 maiselal@dwaf.gov.za
	Head office	Tel: +27 (0) 12 366 7500 Fax: + 27 (0) 12 326 3348 185 Schoeman Street Private Bag X313 PRETORIA 0001

Department	Contact Person	Contact Details
Department of Trade and Industry	**Marba Visagie** Acting Director – Environment Call Centre	Tel. + 27 (0) 12 394 1360 Fax + 27 (0) 12 394 2360 marba@thedti.gov.za Tel: 0861 843 384 Fax: 0861 843 888 Private Bag X84 77 Meintjies Street, Sunnyside Pretoria, 0001
National Cleaner Production Centre	**Ndivhuho Raphulu** Director Head office	Tell: +27 (0) 12 841 3634 Fax: +27 (0) 12 841 5039 Cell: 082 8725348 nraphulu@ncpc.co.za Tel : +27 (0) 12 841 3772 Fax : +27 (0) 12 841 5039 Email: Info@ncpc.co.za Website: www.ncpc.co.za CSIR, Scientia Campus, Bldg 14F Meiring Naude Rd Brummeria PO Box 395 Pretoria 0001

A7.2 TRAINING INSTITUTIONS / FORUMS

Organisation	Further information	Details
The Minerals and Energy Education Training Institute (MEETI)	www.bullion.org.za/	• Provides training accredited by the University of Witwatersrand and recorded with SAQA. • Delivers courses that are compatible with the National Qualifications Framework. • Offers customized, focused events of concern to the leadership in the industry. • Promotes access to courses for historically disadvantages South Africans. • Provides training in environmental issues that could include cleaner production / sustainability
Centre for Sustainability in Mining & Industry (CSMI)	www.csmi.co.za	A centre of excellence in the provision of education and training, and in research, in the fields of Safety, Health, Environment and Community Impact Management (SHEC). Courses range from policy/strategic level sustainable development theory to practical workplace-focused courses, which are presented by academic, consulting and industry experts.
MINTEK	www.mintek.co.za	MINTEK is a leading provider of minerals processing and metallurgical engineering products and services to industries world-wide.

A7.3 OTHER

The following table lists the contact details of the members of the project consortium.

Organisation	Contact Person	Contact Details	Area of Expertise
Digby Wells and Associates	Graham Trusler Skhumbuzo Mzoboshe	graham@digbywells.co.za skhumbuzo@digbywells.co.za	Environmental consulting in mining and metallurgical industry
BECO Institute for Sustainable Business	Bas Kothuis	bkothuis@beco.co.za	Cleaner Production; Sustainability; Auditing; Training; Cleaner Production Forums
Claire Janisch	Claire Janisch	claire.janisch@gmail.com	Cleaner Production; Sustainability
Susan Barclay CC	Susan Barclay	suebar@iafrica.com	Cleaner Production; Training
University of KwaZulu-Natal	Chris Buckley	Buckely@ukzn.ac.za	Cleaner production; water and waste management; life cycle assessment
University of Cape Town	Harro von Blottnitz	Harro.vonBlottnitz@uct.ac.za	Life cycle assessment