



Cleaner Production*

Introduction

UNEP DTIE (United Nations Environment Programme, Division of Technology, Industry and Environment) coined the term “Cleaner Production” (CP) in 1989 as “...the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment” (UNEP 2011). Cleaner Production principles, which are also practiced as waste minimization, pollution prevention, and eco-efficiency, are founded on the four Rs: Reduce, Recycle, Reuse, and Reformulate. This paper is written from the perspective of the private sector and

is to complement a separate paper written for the public sector.

CP can be applied at all decision-making levels in industry. However, the chief focus is the adoption of cleaner technologies and techniques, and is applicable to a wide range of sectors (for example, industry, infrastructure, housing, and hospitality services) and organization sizes (from a large petrochemical plant to a small industrial enterprise). Costly end-of-pipe pollution control systems are gradually replaced with a strategy that reduces and avoids pollution and waste throughout the entire production cycle, starting with product design, and then moving to manufacturing issues such as efficient use of raw materials, energy, and water. It is an especially effective measure for climate change mitigation because of its potential to reduce greenhouse gas (GHG) emissions. Table 1 gives examples.

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Table 1. Examples of Cleaner Production

CP Actions	Examples
A reduction in the quantity of material or energy consumed in manufacturing a unit of product	Certain forging techniques reduce the amount of material required to make the product while also reducing machining energy and waste
A reduction in the hazardous material required to extract a unit of mineral in metallurgical processes	Pre-aeration of ore in water increases efficiency of gold extraction, thereby reducing the use of cyanide
A reduction of materials used in a product	Lightweight bottles and small caps for water bottles
A reduction of air emissions, wastewater, and solid waste generated in production of a unit or product	Resource efficiency as pollution prevention, as in the case of recycling water to achieve zero discharge
A reduction of water and energy use in hospitality services	Water-efficient showers and toilet appliances; low-energy illumination
A reduction of energy use in low-income housing by using green building design	Energy-efficient orientation to maximize the amount of light entering housing units, and shading to minimize use of A/C

CP emphasizes both energy and resource-efficiency improvements, and many of the requirements relating to organization, data, and best practices are the same for both. CP results in benefits for all parties; it protects the environment, the consumer, and the worker while improving industrial efficiency, profitability, and competitiveness.

Description and Application of Cleaner Production

The CP process is an ongoing campaign with continuous benchmarking of performance and improvements, consisting of the following steps (see figure 1):

- Benchmark current resource usage through use of input-process-output analysis.
- Identify (and quantify) opportunities to reduce, reuse, and recycle resources, and to set cleaner production goals.
- Conduct a CP assessment.
- Develop an implementation plan based on the CP assessment.
- Implement the actions of the plan.
- Identify further CP opportunities through new performance benchmarking.



Figure 1. Cleaner Production Process

Cleaner Production Process



Changing an organization’s culture is rarely easy, and overcoming this barrier can be a significant challenge. When implemented within a total corporate sustainability or social responsibility commitment, CP helps to generate waves of innovation that reach beyond the immediate confines of the CP performance objectives.

At first, companies naturally focus their sustainability strategies internally. This is where they have most control, can get the quickest results, and see the direct bottom-line benefits. However, as they assess their total environmental footprint and examine the total flow of resources in the entire chain of economic activity in which they operate, many learn that much of the company’s footprint results from what they buy or sell outside their own operations. These “upstream” activities refer to the entities that supply

products, materials, or services to the company that is assembling either an intermediate or a final product. Where a company sits within the supply chain will often affect its motivation and ability to take actions to improve CP performance among its suppliers.

In some ways, best practices in supply chain CP resemble those applied to internal operations strategies. Leading companies will often offer their efficiency expertise to their suppliers, essentially to support replication of those practices. However, expanding into the supply chain creates substantial new challenges in data collection, analysis, normalization, and reporting. Supply chain efforts are typically much newer, taking formal shape only in the last few years for many companies; these efforts are still in developmental stages for many others. Two key prerequisites apply: (1) the company must both learn how to run an internal CP program and demonstrate its commitment by mounting an effective internal operations effort; and (2) the company must work hard to communicate with its suppliers, explaining why it is asking for data and subsequent commitments, and showing them the benefits of their efforts.

Many companies are improving the energy efficiency of their products and services. Several companies have estimated the energy or carbon footprint of their products and services (the total carbon emissions from products and services over their useful life). Key drivers motivating companies to develop and market more energy-efficient products include pressure from public agencies and advocates, competition, and the push for higher revenue and profit.



There is no single ideal organization chart for successful CP strategies. In fact, the most practical programs seek to fit the CP mission and organization to the company's structure and culture, rather than create a separate organization.

The one common feature of effective CP organizations is that they involve all key functions and operating units in the company. These organizations typically have someone who is identified as the corporate CP/energy manager or CP/energy team leader. They may operate out of environmental health and safety, sustainability, engineering, or operations units. The locus of the team leader is not as important as the way the team is built across functions and operating units. Effective CP team structures are typically cross-functional, multi-level, and matrixed.

When the unit making equipment-purchasing decisions differs from both the unit paying the bills and the facility operations unit, then the barrier known by economists as the "principal-agent" problem stymies CP performance. Companies determined to break through this barrier succeed by building a program that brings these agents together to pursue a common objective. They connect procurement policies with billing systems with facility operations and investment decisions. The motives of all organizational units are aligned under a single goal: meeting and beating the company's performance targets.

Most CP investments are small, and when considered individually can be hard to notice, compared to the many larger investment opportunities corporate

leaders entertain. Winning CP strategies that assess and assemble the potential for savings across multiple facilities and projects can show senior management the total bottom-line value of these investments. This can bring to light ideas that astute individuals may have known about for years, but only when the program made them visible in a meaningful way to senior management do they become actionable.

Prerequisite Factors for Cleaner Production

Champion. A visible 'champion' at management level is a key requirement for a successful CP campaign. The team identifying and implementing CP projects should be comprised of different stakeholders including company experts, external consultants, representatives from shop floor, engineering, finance and management. The campaign must create the necessary tools with rewards, recognition, and incentives to encourage all staff to participate in identifying opportunities and implementing changes in process. A clear communication of the program and all its benefits to the employee, the community, the company, and the environment is essential.

A report sponsored by the Pew Center summarizes the core elements of the best corporate energy efficiency strategies into "Seven Habits" of core practices and principles, cutting across internal operations, supply chains, and products and services (see box 1). Though the study was focused on energy efficiency, its results and conclusions apply more generally to CP.



Box 1. Best Corporate Strategies – Seven Habits of Core Practices and Principles

1. Efficiency is a core strategy.
2. Leadership and organizational support is real and sustained.
3. Company has SMART (Sustainable, Measurable, Accountable, Replicable, and Time Sensitive) energy efficiency goals.
4. Strategy relies on a robust tracking and measurement system.
5. Organization puts substantial and sustained resources into efficiency.
6. Energy efficiency strategy shows demonstrated results.
7. Company effectively communicates energy efficiency results.

Source: Prindle 2010.

Data. Collecting and reporting data is a critical element of any corporate CP strategy. In many organizations, key CP information such as energy and water data simply are rolled into larger operating cost categories, and thus cannot be seen as separate elements. A corporate CP program requires an organization-wide system that tracks units of consumption as well as cost. A standardized set of units is needed to create a consistent basis for performance measurement.

To be useful as a performance metric, resource use is typically normalized by one or more factors the organization considers critical to its overall performance. Normalized energy data is typically expressed as “kWh per X” (kilogram of product, square meter of floor space, or product unit, among others). Beyond normalizing resource use, effective systems also develop baseline usage, typically expressed as performance in a specific year. This

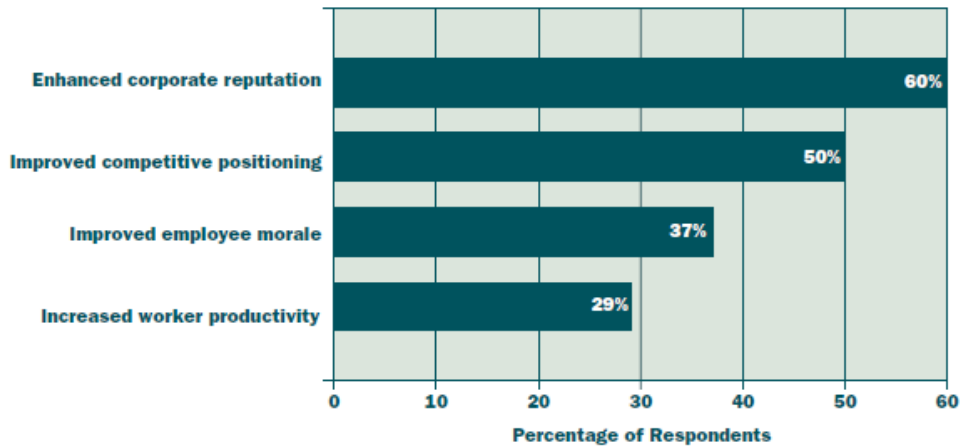
baseline becomes the basis of target setting, and then of measuring progress against the target.

Effective systems must measure performance against goals in regular reporting cycles with data viewed by senior executives with decision-making authority. Facility-level staff must be supported with project data or operating checklist guidance to maintain or improve performance. However, simply reporting information is not enough. Effective programs encourage direct and specific feedback, so that leaders not only see performance information, but also have practical channels through which they can act. Additionally, leaders must know whom to contact in case of a lagging facility or other operating unit.

The best CP programs do not treat their data collection and reporting systems as just a compliance requirement, although they also find that an element of compliance is needed to get broad participation, especially at first. Rather, they tap into a broader cultural ethic of continuous improvement, using the reporting system as a tool that empowers people to seek new efficiencies and associated innovations.



Figure 2. Survey Results: Co-benefits of Cleaner Production (Energy Efficiency) Investments



Source: Prindle 2010.

Advantages and Limitations of Cleaner Production

Advantages. The most compelling benefit of CP is in reducing operating costs and improving productivity for a company. It provides an economic justification for making physical and environmental improvements to a product or process, and it may act as a trigger for innovation at strategic level. In many cases, it enhances market access and prevents market exclusion. Often it serves as a proactive approach to forthcoming legislation.

CP investments provide bottom line value. Companies have found that well-crafted CP investments are highly cost-effective, with rapid paybacks and competitive rates of return, frequently at low cost and usually with low risk. Thus, CP investment decisions are often viewed in simple terms through metrics like “simple payback,” the ratio of annual energy savings to investment costs. Three-year paybacks are about as far as most companies are

willing to go. While companies still use simple payback (Pew Center survey respondents averaged 2.8 years; see Prindle 2010), and other analyses like Internal Rate of Return (IRR) (Pew Center survey respondents averaged 18.5 percent IRR), the best CP strategies today often take other factors, or co-benefits, into account. These co-benefits are summarized in figure 2.

CP investments provide reputational value. Companies are finding that CP, eminently measurable by sustainability indicators, can quickly lead to documented accomplishments that increase reputational value among employees, investors, and other stakeholders.

As the emphasis on water scarcity, climate change and carbon emissions becomes a larger part of the sustainability equation, the fact that energy and water consumption accounts for the majority of most companies’ measured footprints means that CP’s



importance as a sustainability indicator will likely continue to rise.

CP brings top-line benefits: efficiency-driven innovations not only reduce operating costs, they can also drive business growth opportunities. Some companies apply the technologies and practices they innovate internally to their customer offerings, gaining a double stream of benefits.

Limitations. Barriers arise from a combination of the following factors, any of which can impede the uptake of CP:

- Companies' lack of focus on CP.
- Lack of awareness of cost savings from CP and hence reluctance to invest upfront costs.
- Lack of technical ability to identify CP projects and develop these into profitable projects.
- Perception of risk of implementing a technology that may be outside the industry norm.
- Lack of access to finance, although many CP investments require relatively modest sums.

The core of the difficulty lies in the intertwined problems of perceived high risk driving up implicit discount rates associated with projects, high transaction costs, and difficulties in structuring workable contracts for preparing, financing and implementing CP investments. With their main financial benefits focused on savings of energy costs, these cost-saving projects rarely rank as equals with

projects to expand production or capture new markets, especially in rapidly growing economies.

Finding capital is the top-rated obstacle to progress in advancing CP programs. Perhaps the single most effective approach that companies have used to improve access to capital is setting aggressive efficiency goals, making them a priority, and forcing the organization's decision makers to reset their investment priorities to favor efficiency. Many companies have found ways to help efficiency projects are approved as a strategic goal, even when conventional financial analyses make them appear less favorable than other investment options.

Interaction with Other Tools and Possible Substitutes

Opportunities to implement cleaner production can occur at the pre-operational phase or at any point during the project life, at the design stage, or as a retrofit of an existing process. In practice, the greatest gains to be had from cleaner production can be achieved at the earliest stages, as retrofitting is usually more difficult and expensive. However, potentially valuable opportunities are present in existing situations. There are many sources for CP opportunities, which may result from continuous improvement programs such as six sigma and lean manufacturing, as well as from industry standards, product and process engineering groups, and through technical development and research.



Practical Examples of Cleaner Production

Mexico. Vinte Viviendas Integrales is a mid-sized vertically integrated housing developer targeting the medium- and low-income segments of the population in several cities in Mexico. Vinte housing estates feature low-energy lights and solar water heaters. In various estates, Vinte is also installing a photovoltaic system for lighting in common areas and a telemetric system to help owners optimize the use of waste, gas and electricity.

Turkey. Assan Demir, the largest player in the Turkish aluminum sheet, coil, and foil industry, implemented CP projects to improve energy efficiency and product yield at its Tuzla plant. The company invested \$4 million in capital mainly for reducing heat loss in the melting and casting furnaces, and recovering waste heat. Expected benefits include a 6 percent improvement in energy efficiency. Assan also replaced a degreasing machine with a new-generation machine that uses hot water instead of chemicals, thereby reducing environmental impact and improving the quality of the strip.

References and Resources on Cleaner Production

References

Clayton, A., G. Spinardi, and R. Williams. 1999. *Policies for Cleaner Production: A New Agenda for Government and Industry*. London, UK: Earthscan Publications Ltd.
Journal of Cleaner Production. Elsevier.
www.elsevier.com

- Prindle, W. R.. 2010. *From Shop Floor to Top Floor: Best Business Practices in Energy Efficiency*. Fairfax, Virginia: Pew Center on Global Climate Change, ICF International.
http://www.pewclimate.org/docUploads/PEW_EnergyEfficiency_FullReport.pdf
- Taylor, R. P., C. Govindarajalu, J. Levin, A. Meyer, and W. Ward. 2008. *Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond*. Washington, DC: World Bank.
- UNEP (United Nations Environment Programme). http://www.unep.org/resources/business/Focus_Areas/
- USGBC (US Green Building Council). <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1720>
- Yaacoub, A., and J. Fresner. 2006. *Half is Enough: An Introduction to Cleaner Production*. Beirut, LB: LCPC Press.

Resources

The Canadian Industry Program for Energy Conservation (CIPEC), sponsored by Natural Resources Canada (NRCan), has developed a benchmarking and best practices program for Canada's industrial sectors. The program helps industry achieve significant energy efficiencies.
http://oee.nrcan.gc.ca/industrial/technical-info/benchmarking/benchmarking_guides.cfm?attr=24

ChemAlliance.org: "Nuts and Bolts of Chemical Process Pollution Prevention"

ChemAlliance provides information concerning the environmental regulations affecting the chemical industry. ChemAlliance is operated by a partnership of environmental professionals in academia, government, and industry. The "Nuts and Bolts of Chemical Process Pollution Prevention" presentation provides practical strategies for preventing waste and reducing energy consumption in chemical manufacturing facilities. The examples are drawn from more than 400 case studies contained in the ChemAlliance Virtual Plant Tour.



http://www.chemalliance.org/Presentations/nuts_and_bolts_p2/index.asp

EPA South Australia (EPA SA) CP Case Studies

The Environment Protection Authority is South Australia's primary environmental regulator, responsible for the protection of air and water quality, and the control of pollution, waste, noise and radiation. <http://www.epa.sa.gov.au/casestudies.html>

European Bank for Reconstruction and Development (EBRD)

The EBRD's energy efficiency and climate change team works to develop energy efficiency and renewable energy credit lines, to promote energy efficiency in public buildings and industries, and to build a carbon-credit market in the countries of operations. <http://www.ebrd.com/index.htm>

European Integrated Pollution Prevention and Control (EIPPC) Best Practices

The European Integrated Pollution Prevention and Control Bureau (EIPPCB) was set up to organize an exchange of information between Member States and industry on Best Available Techniques (BAT), associated monitoring, and developments within them. The European IPPC Bureau is an output-oriented team that produces reference documents on Best Available Techniques, called BREFs. BREFs are the main reference documents used by competent authorities in Member States when issuing operating permits for the installations that represent a significant pollution potential in Europe. There are about 50,000 of these installations in Europe. <http://eippcb.jrc.es/reference/>
<http://eippcb.jrc.es/pub/english.cgi/0/733169>

Quick PEP Software Tool

The Quick PEP Software Tool is one of the software tools developed by the US Department of Energy Industrial Technologies Program to help US industry improve energy management at industrial facilities. The software is a web-based tool and is available free of charge from this Web

site. This Web page provides an overview of the Quick PEP Software Tool, including intended users, inputs, outputs, availability, and links to more information.

Regional Activity Centre for Cleaner Production

This center based in Barcelona is one of the six Regional Activity Centres (RACs) within the Mediterranean Action Plan (MAP). Each one of these centers is responsible for a specific thematic area. The main goal of the RAC/CP is the promotion and dissemination of prevention, and the reduction of pollution at source in the industrial, agriculture, and tourism sectors. The RAC/CP is situated in the city of Barcelona (Spain).

http://www.cprac.org/eng/01_presentacio.htm

RAC Studies (English, French, and Spanish)

This resource offers a detailed analysis of an industrial sector, and shows its situation and trends in each of the Mediterranean countries. These studies are a tool to encourage the implementation of eco-efficiency in industries. They describe production processes and their environmental impact, while proposing feasible pollution prevention options.

http://www.cprac.org/eng/03_activitats_es_tudis_03.htm#13

Database of Consultants compiled by RAC
http://www.cprac.org/eng/03_activitats_bddsectorials_01.htm

RETScreen International Clean Energy Decision Support Centre

The RETScreen center seeks to build the capacity of planners, decision-makers, and industry to implement renewable energy, cogeneration, and energy efficiency projects. This objective is achieved by: developing decision-making tools (that is, RETScreen Software) that reduce the cost of pre-feasibility studies; disseminating knowledge to help people make better decisions; and by training people to better analyze the technical and financial viability of possible projects.

<http://www.retscreen.net/ang/centre.php>



http://www.retscreen.net/ang/t_training.php
http://www.retscreen.net/ang/t_case_studies.php
http://www.retscreen.net/ang/t_software.php

United Nations Industrial Development Organisation

United Nations Environmental Programme (UNEP) National Cleaner Production Centre (UNIDO NCPC)

UNIDO and UNEP have joined forces to help introduce Cleaner Production in developing countries and countries in transition. The UNIDO/UNEP Programme for National Cleaner Production Centres (NCPCs) is a unique program of capacity development to help achieve adoption and further development of the Cleaner Production concept at the national level.

www.unido.org/index.php?id=o5133
<http://www.unep.org/resourceefficiency/Home/tabid/214/language/fr-FR/Default.aspx>

US Department of Energy Office of Energy Efficiency and Renewable Energy

Best Practices Case Studies
http://www1.eere.energy.gov/industry/bestpractices/case_studies.html
The U.S. Department of Energy (DOE) Save Energy Now Program
<http://www1.eere.energy.gov/industry/saveenergynow/>

US EPA ENERGY STAR

This information center contains energy savings information tailored to industries or focused on specific plant utility and process improvements. ENERGY STAR tools and resources are also available to manage building energy efficiency.

http://www.energystar.gov/index.cfm?c=industry.bus_industry

US EPA Energy Star Energy Performance Indicators (EPIs)

US EPA has developed energy performance indicators (EPIs) for use in several industries' production plants and operations plants. This rating tool is an external

yardstick that enables you to assess how efficiently your plant uses energy, relative to similar plants in the USA. The rating system's 1-100 scale enables company personnel to quickly understand how their plant is performing. For instance, a rating of 50 indicates average energy performance, while a rating of 75 or better indicates top performance. Plants receiving an EPI score of 75 or higher in the USA are eligible to earn ENERGY STAR recognition. EPIs for Food, Glass, Petrochemicals, and Steel are still under development.

http://www.energystar.gov/index.cfm?c=in_focus.bus_industries_focus

EPIs are currently available for these industries:

Cement Manufacturing

http://www.energystar.gov/index.cfm?c=in_focus.bus_cement_manuf_focus

Container Glass Manufacturing Plants

http://www.energystar.gov/index.cfm?c=in_focus.bus_glass_manuf_focus

Corn Refining

http://www.energystar.gov/index.cfm?c=in_focus.bus_corn_refine_focus

Flat Glass Manufacturing Plants

http://www.energystar.gov/index.cfm?c=in_focus.bus_glass_manuf_focus

Frozen Fried Potato Processing Plants

http://www.energystar.gov/index.cfm?c=in_focus.bus_food_proc_focus

Juice Processing Plants

http://www.energystar.gov/index.cfm?c=in_focus.bus_food_proc_focus

Motor Vehicle Manufacturing

http://www.energystar.gov/index.cfm?c=in_focus.bus_motorveh_manuf_focus

Pharmaceutical Manufacturing

http://www.energystar.gov/index.cfm?c=in_focus.bus_pharmaceutical_focus

US Green Building Council

The US Green Building Council (USGBC; see USGBC Web site) is a non-profit organization committed to a prosperous and



Guidance Notes on Tools for POLLUTION MANAGEMENT



sustainable future for our nation through cost-efficient and energy-saving green buildings.

<http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1720>

This guidance note is part of World Bank Group publication: *Getting to Green – A Sourcebook of Pollution Management Policy Tools for Growth and Competitiveness*, available online at www.worldbank.org