3 Pollution

Online student resources

Additional material

Toxic release inventories

There has been a notable reduction in reported toxic intensity in countries like the US, where $1,000 of GDP produced 0.38 pounds of emissions in 2003 but only 0.29 by 2008 (Greener World Media 2010). It is true that this improvement does not apply to all categories of chemicals or heavy metals, and that discharges can vary greatly among sectors. Nevertheless, the proliferation of corporate 'toxic release inventories' (i.e. blacklists of substances that may no longer be used) - because they are carcinogenic, teratogenic, endocrine disruptors, mutagens or persistent bio-accumulative toxins (Hitchcock and Willard 2009) – seems to have had some success in altering corporate pollution behaviour, at least in countries where stringent environmental legislation is in place.

Table 3.1: 2008 US Toxic Emissions by Industry, c.f EPA (Greener World Media 2010)

	in million Pounds
Metal mining	1.157
Electric utilities	910
Primary metals	502
Chemicals	481
Paper	186
Hazardous Waste Management	169
Food, Beverages, Tobacco	167
Petroleum	73
Fabricated Metals	56
Plastics and Rubber	49

This progress should be analysed against the background of the work done in the US by a government body called the EPA Environmental Protection Agency (www.epa.gov/), which was born in 1970 against a backdrop of growing concern about toxicity in the environment. With a remit that consolidated in the late 1970s under Jimmy Carter's presidency, the EPA engagees in public environmental research; sets standards; and enforces regulations. Its accomplishments range "from regulating auto emissions to banning the use of DDT; from cleaning up toxic waste to protecting the ozone layer; from increasing recycling to revitalizing inner-city brownfields. [The end result has been] cleaner air, purer water, and better protected land".

One of the ways in which the EPA achieves its goals is through the TRI Toxic Release Inventory programme that it set up in 1987 and has expanded on several occasions since. As the world's first pollutant release and transfer registry (PRTR), TRI enhances "the public's right-to-know about the disposition of toxic chemicals in communities". The logic here is that regulators and community lobbies are in a better position to police the pollution behaviour of economic actors – first and foremost industrial companies – if information is widely available on the chemical hazards their activities might generate. Controls will be all the more effective since the polluter knows that it is going to be scrutinised. Hence the repeated modifications of the TRI list of toxic chemicals, which has expanded over the years to broaden the list of industrial sectors required to report releases, detail waste management processes and provide detailed information on particularly toxic substances such as mercury or dioxins.

The EPA claims that TRI is the world's oldest and most comprehensive PRTR and has been gradually imitated by more than 20 other countries (Greece, Germany, France, Finland, Estonia, Czech Republic Denmark, Cyprus, Belgium, Austria, Australia, United Kingdom, Estonia, Sweden, Spain, Slovakia, Slovenia, Portugal, Norway, Poland, Netherlands, Malta, Luxembourg, Lithunia, Latvia, Ireland, Hungary, Italy, Mexico and Canada). In addition, the EPA's TRI programme works very closely with a number of global governance bodies such as the OECD Organisation for Economic Development and the UNEP United Nations Environment Programme to help other countries develop or perfect PRTRs by focusing on data collection and release estimation techniques. For further information on coordinated global efforts in this domain, go to http://www.prtr.net/.

Hitchcock, D. and Willard, M. (2009), *The Business Guide to Sustainability: Practical Strategies and Tools for Organizations*, London: Earthscan, 2nd edition

Greener World Media, Inc. (2010), State of Green Business 2010, available at www.greenbiz.com, accessed 5 February 2010

Carbon capture and storage

As revealed in Chapter 2's resource depletion statistics, coal is the one (and possibly only) conventional fuel source offering more than a century of proven and probable reserves at current consumption rates. Interest in coal is also heightened by its prevalence in China, whose rapid economic emergence as the world's manufacturing centre has gone hand-in-hand with enormous demand for new electricity. The end effect in recent years in China has been the opening of nearly one new coal-fired power plant a week. This is a major factor in the International Energy Association's prediction that global demand for coal will rise by 60 percent by the year 2030.

The problem from a pollution perspective is that by some measures, coal is the 'dirtiest' of all possible fuel sources. Above and beyond the killer smog that it causes within local environments, coal is a prime contributor to the greenhouse gas emissions underpinning climate change. Hence the large number of exploratory projects undertaken by governments, scientists and industrialists worldwide to discover technologies making it safe to burn coal - with most attention nowadays being focused on a set of processes known as 'carbon capture and storage' (CCS).

From a technical perspective, clean coal generally divided into different approaches. Post-combustion capture is the "tried and tested way" of removing pollutants from the flue gas that is produced after a fuel is burnt to generate electricity. This usually succeeds in reducing a power plant's CO_2 emissions by 80-90 percent. The problem is that a post-combustion capture plant requires between 10 and 40 percent more energy than a conventional plant (Vidal and Jowit 2009). This is self-defeating in an era of depleting resources.

Hence the growing interest in 'underground coal gasification', where air and steam are pumped below the surface of the Earth to release gases that are directly extracted and burnt in power stations (Monbiot 2007). This is a variant of the broad 'pre-combustion capture' approach where processes start by converting fossil fuels into a mixture of hydrogen and carbon monoxide gases known as syngas before removing the hydrogen gas, a step that leaves two separate streams of pure CO_2 and pure hydrogen (Vidal and Jowit 2009). 90 percent of CO_2 can theoretically be removed in this way, which has the advantage of requiring relatively energy. Two major obstacles remain, however: how to dispose of the CO_2 gases accumulated thusly; and whether the technology can be applied successfully on a commercial scale.

In terms of disposal, storage involves injecting CO_2 gases into microscopic pores of reservoir sediments located somewhere around 800 metres below ground (Haszeldine and Blunt 2010). Four scenarios are usually envisaged: structural trapping, using impermeable cap-rock as a reservoir; residual trapping, where the gases create interstices in rock formations; solubility trapping where they dissolve in water; and mineral trapping, where they react chemically with formation rock. Above and beyond the cost of building pipelines to carry the gas to its disposal sites - usually depleted oil and gas fields or saline aquifers (EC 2008) – there are two concerns: greater leakage of CO_2 when it is injected into old oil fields in an attempt to pressure untapped reserves into production wells (Monbiot 2007); and concerns that injecting gas into enclosed spaces will fracture underground rock formations. Some geologists allay this fear by pointing out that gas can move laterally underground in the same way as oil does, i.e. reservoirs are not closed systems but evolving environments that interact with their surroundings. Thus, the UK is estimated, for instance, to have sufficient geological capacities for storing 100 years of CO_2, enough to cover the output of all power plants in North West Europe. In general, there is an assumption that CO_2 storage can be safe as long as sites are selected carefully and monitored conscientiously. In turn, this gives national governments a role to play in the long-term stewardship of CCS sites. Such policing seems feasible where a regime has jurisdiction over the zone where the work is being done – as occurs, for instance, when European companies engage in C02 storage in their home region. Examples include Norwegian company Statoil's Sleipner project in the North Sea, which is Europe's largest CCS effort; Swedish company Vattenfall's Schwartze Pumpe project at Spremberg Germany, the world's first power plant that collects emissions from coal burning and pipes then deep underground; and French company Total's CCS project at Lacq near Pau in Southwest France. Things can be more problematic, however, when the CCS is occurring abroad, like the In Salah project that a European consortium is running in Algeria.

The problem with applying pre-combustion CCS on a commercial scale is that the technology is still in its early stages. Toshiba's new Oomuta chemical plant on Kyushu Island in South Japan exists solely to practice capturing CO_2 emitted by a coal fired power station next door and has no possibility of disposing whatever gas it accumulates. At such an early phase of technological rollout, the main problem is finding capital to subsidise further research. This can be very challenging given that pilot projects can cost more than $1 billion apiece. Finding ways of funnelling money towards CCS research is particularly important given fears that the recession will undercut government investment in this area. Some argue that firms building CCS power plants should be allowed to raise capital by selling the carbon allowances that they will be acquiring through the kind of emissions trading scheme (ETS) that the EU is developing (Mathiason 2008). Relevant to this analysis is the fact that individual operators – utilities but also CO_2-intensive industries such as cement, refinieries, iron and steel, petrochemicals, oil and gas processing (EC 2008) – are not obliged to adopt CCS, meaning that it could be in their financial interest to avoid CCS altogether and simply pay extra ETS liabilities. "At current technology prices, up front [CCS] investment costs are ca. 30 to

70 percent higher than on standard plants and operating costs are 25 to 75 percent higher...Uptake of CCS will depend on the carbon price and the price of technology. If the price per tonne of CO_2 avoided by CCS is lower than the carbon price, then CCS will begin to be deployed." Otherwise, it may not.

The debate then becomes whether countries devoted to reducing their carbon emissions yet requiring power "to keep the lights on" should be allowed to build more coal-fired plants until such time as CCS becomes commercially viable. This is a particularly difficult argument in a country such as the United Kingdom, which has promised to lower CO_2 emisions by 60 percent by 2050 yet remains dangerously reliant on both gas imports and older domestic 'dirty coal' plants. An example of the latter is the giant Drax power station in Yorkshire (Harris 2007), which by itself produces the same volume of CO_2 emissions as one-quarter of the UK's total fleet of cars (or one-third of its total household emissions). Possible interim solutions include 'co-firing' up to 10% of the plant's output using organic matter and/or fitting sulphur and NOX filters in line with a 'post-combustion' logic. The problem is that the benefits would be marginal and not particularly economic at current pricing levels. Indeed, as aforementioned there is currently an incentive for industrialists to run current plants (and even build new ones, such as EON's Kingsnorth facility in Kent) without CCS and simply pay the ETS penalties, currently calculated to be worth something like £53 million a year at Drax – a sizeable sum but nothing particularly daunting in light of the plant's total revenues (and the cost of developing pipelines and CO_2 disposal sites in the North Sea). This explains why despite so much discussion of the potential benefits of CCS, so little real progress has been achieved.

Despite this (or possibly, because of this), CCS has remained in the headlines as a possible path towards a cleaner future. Notwithstanding the obstacles to the technology's rollout, there is the stark reality of what will happen if it ends up not working. In the words of David Miliband, former British Environment Minister, "Without CCS, the world is going to get much hotter, much quicker."

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Monbiot, G. (2007), *Heat: How Can We Stop The Planet Burning?*, Penguin Books

Vidal, J. and Jowit, J. (24 April 2009), 'Miliband promises new era of clean coal – but who will pay?', *The Guardian*, p. 6

Revision tips

- Newtonian thermodynamics apply to industrial throughput, since all inputs found at the beginning of a manufacturing process will also be present at the end, albeit in a changed form. If an output contains pathogens exceeding a critical threshold of dilution, there will be a pollution problem.
- Pollution can be categorised by origin, depending on whether it is generated from a movable, stationary and/or identifiable source. Issues such as dispersion, biodegradability and mutation (i.e. from solid to gas) form the basis of green chemistry. This knowledge is crucial both to controlling effluents/emissions and to allocating responsibility for clean-up.
- Corporate reporting initiatives are a first step towards pollutant inventories. Analyses can vary by duration of substances' toxicity; the impetus for compiling the inventory (regulatory agencies; corporate compliance; scientific progress). Approaches need to become more exhaustive and standardised, covering both natural and synthetic compounds.
- Companies can no longer afford to blindly externalise their pollution. Risks at this level include ethical responsibilities, reputational capital and legal liabilities. The UK consulting firm Trucost has attempted to quantify benefits that the natural world will provide for free – unless its processes are hampered by pollution.
- Air quality is a longstanding problem that used to materialise mainly in the presence of localised smog pockets. Over the years, there has been a great deal of regulatory progress in this field (exchange of best practices, especially in older industrialised countries) but the sheer volume of emissions are creating the conditions for catastrophic climate change. The main sources of greenhouse gas emissions are manufacturing activities, power generation and transportation, not to mention global deforestation and use of biomass for heating/cooking.
- Land and water pollution can be related, since latter often involves runoffs from the former. Waste sites need better controls – 'stressors' on local ecosystems often seep from them. This explains the growth of international waste management as an economic sector. Information on pollutants' corporate origins needs to be improved.
- There is a general under-estimation of pollution since the visible waste associated with final goods appearing at the end of the value chain usually constitutes no more than a tiny share of total "non-product" waste. Ancillary problems include planned obsolescence and product designs that hinder recycling because synthetic and biological inputs have been mixed up and cannot be separated usefully.
- With a few sectors bearing responsibility for a disproportionate share of total global pollution, concentrating anti-pollution efforts in these areas should

logically produce the greatest effect. At the primary activity level, the main agricultural issues are the over-exploitation of soil and excess of fertilisers/pesticides, with the main mining issue being the treatment of slurry. Where secondary activities are concerned, most progress will be achieved at process level, including the use of non-toxic or biodegradable inputs, enhanced vigilance concerning a value chain's total footprint, etc.

Case study: The Great Pacific Garbage Patch

Explorers and other hardy souls braving the frontiers of nature have often provided valuable information about how human activity affects planet Earth. Some fact-finding occurs during organised expeditions, like when scientists are dispatched to the North or South Pole to ascertain the effects of climate change by studying the rate at which icebergs and glaciers melt. On other occasions, knowledge is gathered by happenstance. A prime example was in 1997 when American sailor Charles Moore, participating in a Hawaii to Los Angeles boat race, decided to navigate through a windless zone called the 'North Pacific Gyre' and encountered an enormous vortex of plastic and other rubbish now known as the Great Pacific Garbage Patch – a manmade huge sea of detritus smothering the marine ecosystem.

That such an enormous "plastic soup of waste" now covering an area equivalent to twice the size of the continental United State (Marks 2008) can even exist reveals the failings of a municipal waste management sector that is often portrayed as a mature international business activity. There is no doubt that general understanding of waste disposal has advanced greatly since the days when many communities, even in the world's wealthier countries, were happy to simply dump their waste at what they considered safe distant from human habitat (i.e. Victorian sewage drainpipes). Cities in the world's wealthier countries no longer feature the sort of open gutters that once caused so much infectious disease and early death. Indeed, the success of some of today's leading municipal sanitation companies, such as France's Ondeo or Vivendi groups or the American multinational Waste Management, is rooted in their decades of global experience treating sewage and separating it from drinking water. Of course, many cities in the world's poorer countries continue to lack an effective waste disposal infrastructure. Nevertheless, the general outlook in this sector has been optimistic: new economic powerhouses are emerging with sufficient capital to fund infrastructure improvements; intergovernmental organisations such as the World Bank provide grants to the world's poor countries; and technological progress (i.e. anaerobic digestion) is being used to reduce waste's overall toxicity. There is hope that cities everywhere will soon be able to replicate the success that places such as Hamburg or Liverpool have had in restoring fish stocks in rivers (respectively, the Elbe and the Mersey) that were once effectively dead.

This optimism is being dampened by the recurrence of deadly oil and chemical spillages in rivers ranging from Germany's Rhine to China's Yangtze. Most horribly, there has been the recent discovery of the Great Pacific Garbage Patch. Eighty percent of this sea of waste stems from terrestrial sources on both the Asian and American sides of the Pacific (only twenty percent involves items thrown off ships or oil platforms). This means that many cities are at fault for the eco-disaster, reflecting either the inadequacies of their waste disposal systems and/or a deliberate flaunting of the 1972 London 'Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter' (www.imo.org/). It is one thing to outlaw unhealthy practices. It is quite another to police them.

The plastic soup in the Pacific is particularly worrisome because its decomposition releases into the marine ecosystem a noxious cocktail of chemicals including bisphenol A, which disrupts animal hormonal systems; styrene monomers, known to cause cancer; and styrene dimers and trimers, suspected of having the same effect (Connor 2009). These compounds enter the food chain of marine organisms, hence of their predators: larger fish; waterfowl; and ultimately, humans. Municipalities may once have had the luxury of outsourcing waste disposal to private companies whose barges would then cart tonnes of rubbish out to sea but such benign negligence is no longer possible. However vast the planet's oceans are, they have become too small to absorb human pollution.

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■ Case study questions

A. Describe this ecological catastrophe and why there is so little talk about it.

B. What is the outlook for cleaning up this detritus?

C. What might be done to prevent recurrence of the waste disposal behaviour that created this problem?

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