PART ONE

BACKGROUND
INTRODUCTION

Background Geography
Kanpur lies in the north of India in the state of Uttar Pradesh (UP), the largest state by population in the country. The districts of Unnao in the north, Hamirpur in the south, Fatehpur in the east and Etawah and Farrukhabad in the west define the boundaries of Kanpur. On April 23, 1981 Kanpur was subdivided into Kanpur city and Kanpur dehat (village) (Indian Statistical Department, 1993). It is between Delhi, about 425 kilometres to the west and Calcutta about 1,000 kilometres to the east. The city is a major industrial centre of the north and used to be referred to in the past as the Manchester of Northern India. It is located on the banks of the Ganga in the centre of the Ganga plain, and is well connected to the rest of India via rail and road. Kanpur is on the Grand Trunk Road from the North West Frontier to Calcutta.

The climate of the city is subtropical monsoon and average temperatures range from a low of 19.5°C in January to a high of 35.6°C in May. It is 800 kilometres from the nearest sea coast. As in the case of the classical monsoon climate, almost 80 percent of the rain falls in the rainy months of mid-June, July, August and partly September. The April to June season is extremely hot and dry.

\footnote{This introductory section has benefitted extensively from S.N. Singh, Planning & Development of An Industrial Town, Mittal Publications, New Delhi, India, 1990. It has been updated as a result of our work in the city under the Project in 1994 and 1995.}
The 1991 population of the city is approximately 2.4 million and includes 381 thousand who are determined to be in the “rural” portion of the city (KMC, 1994, p.1). Singh (1990, p.42) reports a 1971 population of 1.3 million, presumably referring to the urban portion of the district only. This suggests an annual rate of population growth of approximately 2.2 percent per annum from 1971 to 1991. Tiwari (1995) suggests that rates of population growth have progressively declined since 1931-1941, primarily as a result of the reduction in rates of immigration. There has been some growth in geographic area and population of the city over the years, through the annexation of neighbouring areas. The two original urban components of the city (Kanpur City and the Cantonment) were joined by five other urban centres (Rawatpur Station, Central Railway Colony, Armapur Estate, Northern Railway Colony and Chakeri) to form the Kanpur Urban Agglomeration.

History
Kanpur was declared as the district headquarters in 1801. It was a focus for industrial development from the beginning with indigo and cotton as well as tanneries mentioned in the period prior to 1850. By 1850, the city had added new communications (rail link to Allahabad) and public sector service facilities and the population had grown to over 100,000 (Singh, 1990, pp.9-35). Following the first war of independence (also known as mutiny) in 1857, a conscious policy to promote Kanpur as an industrial centre was developed. This was seen as an employment generation strategy which would reduce the tension in the areas around the city after the rebellion. The focus of the city on industrial development including tanneries, textiles, agricultural processing continued. Chemical and metal processing had been added to the city’s industrial base by the end of the century. The city remained best known for its textile and leather industries.

In the period up to the second world war, the city expanded at a rapid rate, eclipsing other northern cities and becoming the industrial development centre of the north by the 1940’s. Both the first and second world war efforts contributed to the growth of industry in the city as industries produced at full capacity to support the war effort. These were times of rapid growth in industrial employment in the city.
During the period from 1900 to 1945, industrial representatives and city officials recognised the particular needs of labour associated with the industrial development. They cooperated to construct labour colonies associated with the industries where improved housing and sanitary conditions for workers were the main objective. Although there is considerable reference to sanitary conditions and sewers for worker housing, there is little reference during this time to environmental concerns associated with the industrial development itself.

**Industry and Economy Today**

In the period from 1945 to today, the number of industries continued to increase while employment stabilised and then began to decline (Singh, 1990, pp.25-26). Despite these trends, we still find a city today where textile industry remains important but is facing increased competition from other countries and regions. Engineering and livestock-based industry follow in importance.

Although the textile industry is on the decline it remains supreme in terms of the number of employees and number of establishments. The majority of the workers are in the cotton mills. Leather and leather goods industries in the state of Uttar Pradesh are strongly concentrated in Kanpur (Singh, 1990, pp.57-60). The chemical and chemical products industries and the metal and metal-based industries are more recent additions to the industrial fabric of Kanpur. Both industrial groups were present from the turn of the century but have grown in significance in the post war years. Both are growing rapidly and providing some new jobs to replace some of those being lost in the textile sector.

The industries can be grouped into three categories with respect to their spatial location in the city. First, the old industrial complex, established prior to 1930, has now been surrounded by city growth. It includes an inner zone on the river front where large scale industries established in the late 1800's and early 1900's remind us of the British influence. This complex includes mainly textile mills and tanneries and approaches the edge of the Central Business District of Kanpur. Second, the pre-independence outlying industrial areas developed because of cheaper land, reduced congestion and lower land costs and taxes. It included defence industries, iron and steel works, chemical plants and aircraft industry. Third, the planned industrial estates are outlying organised industrial estates with smaller industries. Industries located here include: electrical, base metals, pints, agricultural implements and fertiliser (Singh, 1990, p.76).
With respect to the administration and management of Kanpur and area in 1995, the Kanpur Urban Agglomeration is approximately 300 square kilometres. A larger area including the city and surrounding area is under the management of the Kanpur Development Authority and includes 829 square kilometres (KMC, 1992, pp.1-2).

CONCLUSIONS

During the formative years of the development of the industrial complex of Kanpur, environmental conditions associated with industrial development were not a major concern. The people of Kanpur and area were concerned about finding jobs and the employers about profits. As the city grew in importance because of its industrial development, concerns for the health and wellbeing of workers came to be important. This was mainly reflected in attempts to improve the quality of available housing through the development of labour colonies.

Today, Kanpur Urban Agglomeration authorities are concerned about various aspects of environmental issues i.e., drinking water, sanitary conditions, drainage, environmental health, congestion (due to crowding and transportation), industrial, commercial and domestic waste, and workers health and safety to name a few. With respect to the waste produced by the industrial and commercial sector, a variety of approaches are important including the principles of reduction and recycling and the use of efficient waste management processes. One of the ways to deal with the waste management issue is through the use of low waste technology. Subsequent papers in the book outline various considerations in the implementation of sustainable development and the use of low waste technology for Kanpur industry.
REFERENCES


LOW WASTE INDUSTRIAL TECHNOLOGIES:

IF IT IS A LOW HANGING FRUIT,

WHY DOESN’T INDUSTRY PICK IT?

N.T. Yap and I. Heathcote

“Protecting the environment . . . is not a zero sum game. Many forms of pollution reflect underutilised or wasted resources.”

W. Esty, Associate Professor, Yale University 1994

“Win-win is a wonderful concept. It implies the economic oxymoron, a free lunch.”

F. Cairncross, Environmental Editor, The Economist 1994

INTRODUCTION

The industrial economy is essentially linear. Economic wealth is derived from the linear and unidirectional flow of resources. Many of the resource inputs are non-renewable. Wastes arise from each stage of this unidirectional flow, from the extraction and purification of raw materials, the manufacturing process, the utilisation of these goods, to the ultimate disposal of products at the end of their life cycle. Two serious problems have resulted from this linearity: (a) resource depletion, and (b) environmental degradation resulting from the wastes. International trade and aid have globalised the problems. Fundamental changes are required. Technologically there are two possibilities (Johansson, 1993):
(a) creation, in a thermodynamic sense, of a closed industrial system which exchanges only energy (no material) with nature. Product flows return to and are fully reprocessed and recycled in the industrial system, and
(b) restructuring of industrial production to make it totally compatible with nature, using only renewable raw materials, “soft” technologies, and producing biodegradable products.

Low waste technologies (LWTs) are technical changes in this direction. These technologies introduce feedback loops through good housekeeping practices, reuse, process modification, recycling, recovery, materials substitution, enhanced product durability, minimal and standardised consumer packaging (Cf. Figure 1.3 in Introduction). LWTs may be grouped under eight categories (Cf. Table 1.1 in Introduction). The concept is described in the literature by several names: “non-waste technologies”, “clean(er) technologies”, “clean(er) production”. LWTs have the potential to provide financial returns through the reduction of resource inputs per unit of output, sale of secondary materials, reduced costs for storage, transport and disposal of waste as well as reduced liability insurance. By creating safer workplace environments worker health costs can arguably be reduced.

Objectives of the Paper
An analysis of the evolution and effectiveness of public policy response to the problem of industrial waste in Europe and in North America is important if Low Consumption Countries (LCCs) are to “leapfrog” some of the serious problems associated with industrialisation.

LWTs exist for a wide range of industrial sectors, but the extent of their adoption by industry remains low even in countries in the Organisation for Economic Cooperation and Development (OECD), with the outstanding exception of Japan and Germany. End-of-pipe (EOP) technologies remain the preferred option of industry even where LWTs are available and affordable. The question this paper seeks to answer is why? How can LWT adoption by industry be systematically and effectively promoted?
Organisation of the Paper
Section I describes the nature of the industrial waste problem and the evolution of public policy response to the problem. Sections II and III present successful cases of integrating the private sectors’ profit seeking objectives with the public’s interest in environmental protection. An analysis of the barriers to the wider adoption of LWTs is given in Section IV. The paper concludes with a discussion of how these barriers might be addressed or bypassed.

I. THE INDUSTRIAL WASTE PROBLEM AND END-OF-PIPE RESPONSES

Reliable quantitative data on industrial (and municipal) waste is difficult to obtain. However it is generally accepted that more than one billion tonnes of hazardous wastes are generated globally every year, with North America contributing about 30 percent (Jackson, 1991).

Public concern over industrial wastes has grown during the past three decades despite the fact that the link established between chemicals and human health problems is more correlative than causal. In the eyes of many among the public, the outbreak of Minamata disease in Japan in the late fifties, its occurrence in Ontario native communities in the mid-seventies, and the seal “kill” in the southern North Sea provided sufficient indications of the serious human and animal health threats posed by long-term exposure to certain chemicals. The short-term implications have been more readily accepted as a result of disasters such as the Torrey Canyon and Bhopal.

The ecological and health implications of chemical dispersion in the environment are complicated by several factors. First, very little is known about the toxicity of these chemicals. There are approximately 70,000 to 100,000 chemical compounds in commercial circulation with 2,500 new ones added every year (Freudenberg and Steinsapir, 1992). Inevitably these chemicals end up in the environment at some point in their life cycle. Less than 1 percent of chemical compounds
in commercial use have been adequately studied in terms of their toxicity (NRC, 1984). Second, the health impacts of chemicals have long lead times and hence causality is difficult to establish. Third, there remains inadequate understanding of how most of these chemicals flow through the environment and into the food chain. Finally, society’s chemical use is not only increasing in volume but also in diversity, complexity and in some use areas, in toxicity (NRC, 1984).

The conflict between environmentalists and industrial waste producers has generally been based on a shared premise that the ratio of industrial production to industrial pollution is fixed. The trade-off between production and pollution is inevitably a zero sum game. Consensus is not easy to achieve since the stakeholders represent fundamentally different positions on what constitutes acceptable environmental quality. Pollution control policy discussions involve balancing economic growth against pollution. The response of industry has typically been to add, at the end of the pipe, technologies that mitigate the environmental impacts of industrial processes and residuals – scrubbers, containment lagoons, waste neutralisation and treatment systems, deep-well injection, engineered landfills, and incinerators – or to rehabilitate sites after they have been polluted.

Failure of EOP Responses
In 1988 Barry Commoner evaluated 15 years of pollution control regulations in the United States. Reviewing annual Environmental Protection Agency (EPA) air and water quality data from 400 sampling stations, Commoner reported that environmental quality had barely improved in 80 percent of the test sites. In some sites it had even worsened. This despite clean up expenditures amounting to $100 billion in that fifteen-year period (Geiser, 1991). Also in 1988 the U.S. General Auditing Office estimated that there were between 130,000 and 425,000 contaminated waste sites in the U.S., although less than 1,500 are listed in the Superfund National Priorities List (Freudenberg and Steinsapir, 1992).

The notion of foresight or Vorsorge entered the public debate in Germany in the early seventies and became the foundation of German environmental policy since then (O’Riordan, 1994). This “precaution” principle with its ethical and economic implications likewise influenced the position of environmental groups in North America. “Better to be roughly right in due time than to
be precisely right too late” became the theme of many environmental pressure groups that mushroomed in North America in the seventies. It did not however influence policy-making in North America to the extent it did in Germany and, increasingly in the European Union (EU) countries. Not until the emergence of grassroots community-based environmentalism in the U.S. and Canada in the late seventies did pollution issues enjoy the same prominence in the environmental policy agenda as wildlife conservation and nature preservation issues (Freudenberg and Steinsapir, 1992).

The evolution of the U.S. government policy is indeed instructive. No serious attention was given by the government to pollution prevention strategies until the eighties when opposition to the siting of waste disposal sites became more vehement and better organised at the community level. In 1986 the U.S. federal government allocated only $4 million on waste reduction out of its $16 billion environmental protection expenditures. That same year however, saw an influential report from the Office of Technology Assessment advocating a shift from pollution control to pollution prevention. A special office for Pollution Prevention was established in 1987 to guide the EPA programs.

By 1990 comprehensive waste reduction laws were enacted in several states and the U.S. Congress passed the Pollution Prevention Act (Geiser, 1991). In 1992 the U.S. government mandated federal defence research establishments to release and transfer “clean technologies”, presumably developed in these institutions during the cold-war era, to small- and medium-sized U.S. industries to improve their “global competitiveness”. The government has also used development assistance channels to fund IWT initiatives in Asia for the purposes of securing markets for U.S. environmentally-friendly technologies.

The consequences of the failure of EOP responses continue to unfold. Data reported under the U.S. Access to information legislation indicate that every year U.S. industries release more than 2.7 billion pounds of toxic chemicals into the atmosphere, including more than 300 million pounds of suspected carcinogens. According to the U.S. EPA, more than 90 percent of Americans have measurable quantities of suspected or confirmed carcinogens in their bodies (Freudenberg and Steinsapir, 1992).
The real economic costs of the failure to reduce the production, consumption and disposal of toxic chemicals are translating into clean-up costs estimated to be $10 billion for Germany and $1.5 billion for the Netherlands. Estimates in the U.S. range from $20 billion to $100 billion (Jackson, 1992).

II. INTEGRATING THE ENVIRONMENT AND THE ECONOMY

The failure of EOP responses was predictable. In 1977 Schultz had written:

If, for example, we assume that per capita living standards in the United States, improve from now on at only half the rate of the past century, the gross national product a hundred years from now, will still have risen by more than threefold... Only if pollution per unit of output is cut by two-thirds can we maintain current environmental performance, let alone improve it.

Schultz saw both policy and technology shifts as crucial:

In the long-run the future of society is going to hinge on the discovery and adoption of ever-improving technologies to reduce the environmental consequences of expanding production... The institutions and incentives of society have to be modified for a steady long-run effort. Reducing pollution has to become a paying proposition rather than just another battle against the regulators (emphasis and italics added) (1977, p.77).

Unfortunately these shifts have not come about. The 1970-1980 period was an era of what has been termed “resistant adaptation”, characterised by the failure of industry to internalise environmental issues in their business strategy (Walley and Whitehead, 1994). There were striking exceptions, the best known being the 3M Corporation which recognised in 1976 that pollution control compliance costs were threatening its profitability. It redirected its environmental control strategies to what are called “low waste technologies” or alternatively “clean technologies”.

In the 15 years since 3M Corporation established its Pollution Prevention Pays Program (3P), it has reduced its waste generation by 50 percent – annually cutting down 126,000 tons of air emissions, 16,600 tons of sludge, more than 6.5 million litres of wastewater, 409,000 tons of solid and hazardous wastes, and an equivalent of 210,000 barrels of oil in energy consumption. The 3P Program has reportedly saved 3M Corporation more than $506 million from 1975 to 1990. Management believes a further 30 percent waste reduction is possible (Huisingh and Baas, 1991).
Other firms followed. The work of Royston (1980) publicised the early successes. Between 1989 and 1991 Texaco, using LWTs, achieved a 40 percent reduction in its air water and solid waste streams, and 58 percent reduction in toxic wastes. During the same period Georgia-Pacific achieved a 65 percent reduction in dioxins and a 34 percent reduction in chloroform emissions through materials substitution and processes (Harvard Business Review, 1994). By switching to a water-based solvent in coating medicine tablets, Ricker Laboratories (U.S.), a pharmaceutical plant, reduced its air pollution emissions by 24 tons a year, saving the plant $180,000 in pollution control equipment it would have needed to meet California’s environmental regulations. Broyhill Furniture Industries (U.S.) replaced a conventional spray-finishing operation with an electrostatic finishing system that applies a sensitising agent to furniture to attract finishing chemicals. Broyhill reduced its finishing and clean-up material costs by 20 percent leading to an annual savings of $150,000 (P2, 1994a; P2, 1994b).

In 1991 the cost and benefits of source reduction measures in twenty-nine organic chemical manufacturing plants in California, New Jersey and Ohio were analysed. The firms varied in size, products, processes, and markets. One hundred and eighty-one low waste initiatives were documented. The average reduction per waste stream was 71 percent, average increase in product yield 6.9 percent, average annual savings per initiative $351,000, average annual savings per dollar invested $3.92, average payback period 13.2 months, and average length of time to accomplish 8.2 months (Backman et al., 1989).

In Canada some of the most high-profile cases in recent years have come from the automobile manufacturing industry, as a result of a voluntary agreement signed between the Canadian Motor Vehicle Manufacturers’ Association (MVMA), Environment Canada and the Ontario Ministry of Environment and Energy (MVMA Project, 1994). The St. Thomas (Ontario) Assembly Plant of the Ford Company recently introduced a Total Fluids Management Unit Cost Billing Program providing economic incentives for the reduction of solvent use. The program uses a team approach whereby suppliers are paid on the basis of the number of vehicles rather than on chemical usage. The supplier provides full-time technical representatives in the customer’s facility.
(the Ford Company), develops operating and maintenance schedules, provides technical training, and participates in joint teams to achieve environmental and economic objectives. The program has resulted in reduced loadings of chromium (by 2,566 lbs./yr), nickel (by 991 lbs./yr), zinc (by 615 lbs./yr), and phosphate (by 8,425 lbs./yr). There was also an elimination of all solvent-based pre-cleaners (equivalent to about 120,000 lbs./yr of volatile organic compounds), reduced water consumption by 27 million gal/yr, and reduced metal-bearing paint sludge by 500,000 lbs./yr. While the costs of the program have been minimal, the annual savings are estimated at over U.S. $200,000.

Chrysler Canada Ltd. has also achieved success with LWT, winning recognition throughout the auto industry and securing the Essex County Waste Management Award of Merit three years in a row. Chrysler’s Pillete Road Truck Assembly Plant manufactures full size Dodge trucks, using hazardous and non-hazardous sealants in the assembly process. By expanding the use of reusable sealant totes with plastic liners, the plant eliminated sealants wasted in empty drums. Overall the program resulted in net savings of $50 a drum. Labour and additional costs associated with manually scraping the hazardous drums were also eliminated. Total annual savings for the plant are estimated at about U.S. $30,000.

General Motors of Canada Ltd. shifted to water-based paints for building and equipment maintenance, eliminating the use of naphthalene, toluene and xylene. The program has resulted in a reduction of 21,500 lbs. of solvent released during building refurbishment. It eliminated the need for special solvent-based storage facilities. The water-based paints cost more but spread further. Painting can now be done during daylight hours because the paint odour poses no health hazards to workers. The plant has also eliminated 100 percent of the grinding sludge, or swarf, created in the grinding and finishing of aluminum automotive transmissions. Previously landfilled, the swarf had 85 percent metal content and thus had potential value as feedstock. By introducing a simple defluidising unit into the process, the plant has saved $60,000 annually in reduced waste transportation and disposal costs. Now, 430 tonnes of aluminum grinding and 495 tonnes of iron/steel swarf are diverted from landfills and sent to a metal recycling operation.
Smaller operations are also demonstrating that LWT can yield financial benefits at low cost. Kelly Auto Body, an automotive serve and collision repair operation in Hamilton, Ontario found that minor housekeeping changes, and a capital expenditure of $12,000 spread over several years, resulted in significant savings. Process alterations included liquid masking (replacing paper and tarps), and the use of high-volume low-pressure paint sprayers. Liquid masking saved labour and improved quality. The low-pressure sprayer reduced paint costs, air emissions and filter changes. Savings also resulted from solvent collection and recycling (savings of $2,000 a year), bulk purchases of engine oil and antifreeze, and the use of recycled oil, antifreeze, tires, batteries, cardboard, containers and scrap metal.

Court Galvanizing Ltd. won the Ontario Waste Management Corporation’s 1992 Award of Merit for outstanding waste reduction activities. A conventional hot-dip galvanizing operation, Court introduced a sulfuric acid regeneration and rinse recovery system, reducing water use by 50 million litres a year. A separate recovery system removes iron and zinc from the sulfuric acid used in the galvanizing process and produces a ferrous/zinc sulfate by-product that can be used in the fertiliser industry. The system cost about $500,000 but has significantly reduced sewer use charges and sulfuric acid use. Acid disposal costs have been completely eliminated.

The experience of European firms is similar. A Swedish manufacturer of electrical light fixtures, under pressure from the government to reduce its volatile organic carbon emissions, converted to powder paints. The conversion cut down the painting costs by 50 percent and saved 204,000 Swedish Kronas (U.S. $29,000) in start-up costs for the combustion system it would have had to use. In Poland a medium-sized automotive-parts manufacturer introduced changes that cut down its heavy metal wastes production and water consumption. The investment of $17,800 was recovered in less than a month with annual savings of $223,000 (Backman et al., 1989). In the Netherlands the costs and benefits of LWT options generated and implemented through a government-funded, industry-university collaboration were analysed. Of the forty-five implemented options, twenty had benefit-cost ratios greater than 1 and nineteen were neutral (De Hoo and Dieleman, 1992).

Similar reports of enhanced profitability from LWT adoption among firms in LCCs are being added to the literature (P2, 1994a; P2, 1994b). The paper by El-Tayeb, Cummings and
Siddiqui in this volume document, in unusually careful detail, the profitability of low waste strategies adopted by some firms in Kanpur, India. The cost-benefit analyses of these changes, however, are rarely published. For instance, in India the financial benefits from the use of biomethanation process at the Central Distillery and Breweries Ltd. in Meerut and at the Government Medical College in Nagpur have not been reported. The benefits are presumed to be substantive since the process not only cuts down chemical inputs but also generates biogas for energy.

Reports such as these have led to intense interest among governments and environmentalists in clean production. Many draw on the credibility of sympathetic economists such as Harvard Business School Professor Michael Porter who had written that “strict environmental regulations do not inevitably hinder competitive advantage…indeed, they often enhance it” (Porter cited in Walley and Whitehead, 1994, p.48). The literature on the science, economic benefits and policy dimensions of clean production has increased significantly both in volume and rigour in the last six years.

III. DIFFUSION OF LWT

The adoption of LWTs has not always been driven by strict environmental regulations. In some cases it has been triggered by purely profit-seeking interest; in others it has been presented as a moral responsibility. Swire Pacific in Hong Kong had an environmental audit done. The audit showed sources of energy waste. Better energy management led to a savings of 7-10 percent of the energy bill, normally U.S. $260,000. As a cost-cutting measure, a fish canning plant in the Philippines started processing their press liquor to extract fish oil which they later refine for use in prawn feed, as a substitute for cod liver oil, and in other industries such as leather paints, to use as lubricants. The company proceeded to use some of the wastewater as raw material for producing fish sauce (Lirag, 1993). In Kanpur a tannery that systematically adopted process modifications and installed chrome recovery in its operations, stated at an interview with one of the authors (Yap) that
management introduced the changes because it sees environmental protection as a "moral responsibility". The chemist at a Kanpur dairy who had been instrumental in introducing low waste changes in the plant, including establishment of a plant nursery to make use of discarded plastic bags, and sludge from the effluent treatment plant (see Howland's paper in this volume) cited "love for flowers and a healthier workplace" as his main motivation.

**Country-specific Studies**

Some countries have put in place low waste technology programmes. Denmark, France, Germany and the Netherlands established “Cleaner Technology Programmes” in the early eighties. Sweden initiated a Cleaner Technology pilot project in 1987 and Norway, Austria and the United Kingdom in 1989. They have had varying effectiveness. What lessons can we draw from them?

**Netherlands (PRISMA):** Direct involvement of the government in cleaner production technologies started in the early 1970s (Craemer et al., 1990; De Hoo and Dieleman, 1992; Dorfman, 1991). A charge system for industrial wastewater was introduced along with the establishment of emission standards.

The National Environmental Policy Plan established waste reduction targets of 50-90 percent of the 1988 waste emissions by 2010. Waste generators are encouraged, with financial support from the government, to develop in-plant “Environmental Care” systems. If voluntary efforts fail, regulations would be introduced. Eighteen “Innovation Centres” in the different industrial regions of the country were established to transfer LWT to industrial firms.

This was the policy environment in which a two-year research project on low waste approaches, PRISMA, was launched in 1987 by the Netherlands Organisation of Technology Assessment (NOTA). It involved the Netherlands Organisation for Applied Scientific Research Centre for Technology and Policy Studies (TNO), Erasmus University Centre for Environmental Studies (ESM), and the Interfaculty Department of the University of Amsterdam (IVAM). Ten experiments were carried out in 10 companies in the Amsterdam and Rotterdam areas. The companies were selected from the food industry, electroplating, metalworking, public transport and chemical industry. The project was managed by NOTA with funding from the Ministry of Economic Affairs and the Ministry of Housing.
Waste Management and Sustainable Development in India, Yap and Awasthi

Under the supervision of the PRISMA researchers waste audits were conducted, waste reduction options investigated for technical and financial feasibility, and where appropriate, waste reduction programmes implemented. A detailed cost-benefit analysis was made for each option implemented. Policy studies were conducted by IVAM, ESM and TNO. Of the 164 options considered feasible, 45 were implemented within less than 1.5 years (De Hoo and Dieleman, 1992).

Sweden (LANDSKRONA): This research project, initiated in 1987, involved an environmental research organisation, TEM, within the University of Lund and seven small and medium-sized industrial firms in Landskrona (Backman et al., 1989). The goal was to explore the possible economic and environmental benefits of using systematic preventative approaches to reduce waste and risk. Funding was provided by the Foundation of REFORSK, the National Swedish Board for Technical Development (STU), the National Swedish Industrial Board (SIND) and the local authorities of Landskrona.

The firms were selected from the graphics, metal working and chemical industries. The project was launched with a workshop introducing the low waste concept and successful case studies to the executives of the participating firms. Detailed procedures were developed for each firm. In-plant discussions were held with individual firms to further clarify goals, procedures and timetables for the research. The procedure included undertaking a complete mass balance and developing production and process flow diagrams thus allowing for a comprehensive waste profile and audit to be done. The firms were encouraged to adjust this evaluation to their particular context. A detailed cost-benefit analysis was done on each implemented option, and the results shared with other firms in the sub-sector through conferences or workshops.

Perhaps one of the most valuable insights from the LANDSKRONA experiment was the indispensable role of a good waste audit in identifying opportunities for waste reduction. One of the highlights of this research was the work with a firm that manufactures lighting fixtures for interior and exterior applications. The wastes of concern were trichloroethylene (TCE) from degreasing operations, petroleum-based lubricating oils used in metal cutting and hydraulic pumps, chromates and phosphates, and solvent-based paints. In the process of searching for an alternative to TCE, the entire production process was examined. A switch from petroleum-based lubricants to
Biodegradable oils emerged as a feasible alternative. Not only did this eliminate the use of non-biodegradable lubricant, it also totally eliminated the use of TCE, a hazardous waste. The biodegradable substitute is easily removable by a mild detergent.

Denmark (Kalundborg): The concept of closed loop systems has been extended beyond plant boundaries in Denmark (Ferro, 1994). Four major companies in Kalundborg experimented with a program of “industrial symbiosis”. At the centre is the town’s power plant. Some of the power plant’s waste steam is channelled to the nearby pharmaceutical plant for its fermentation process that produces insulin, and some to an oil refinery. Its excess heat provides energy for 5,000 households. Warm water from the power plant is used to warm fish tanks in which salmon and turbot are raised for export. The pharmaceutical company producing insulin delivers the sludge from its operations to local farmers, saving them $60 per acre of fertilizer costs. The oil refinery in turn delivers approximately one ton of gas per hour (that it would have “burned” off) to the power station, reducing its coal consumption by 30,000 tons per year. The oil refinery also sends its cooling and wastewater to the power plant, reducing overall water consumption. The final link in this symbiosis is a plasterboard factory which receives surplus gas from the refinery and gypsum from the power plant (a waste product of power plant sulfur dioxide scrubbers).

What these different programmes demonstrate is that the barrier to the adoption of LWTs is rarely technical. Paradoxically, just as LWTs are being vigorously promoted in LCCs by some development assistance agencies, a “backlash” appears to have developed, at least in North America, against the whole notion of “win-win” scenarios. Voices are beginning to be heard from the academic and professional community who challenge what they described as the “Pollyanna” view (Walley and Whitehead, 1994; Harvard Business Review, 1994; Passent, 1994; Van den Broek, 1994). If LWTs are technically feasible and demonstrably more cost-effective than EOP technologies why have they not been widely adopted? Why is a backlash emerging?
IV. BARRIERS TO DIFFUSION

This strongest barriers are non-technical and may be grouped under four categories: (a) attitudinal (b) financial (c) organisational and (d) systemic.

Attitudinal
There is widespread ignorance or scepticism among waste generators of the potential financial benefits of low waste approaches. Waste management is generally assigned to middle level managers who tend to avoid the risks of unfamiliar technologies. Many also do not wish to be seen by higher management as not having done their jobs adequately. Some of the waste management routines become sacrosanct through the years and any change can be perceived as a threat in the workplace (Yap, 1988). This reluctance to change is especially true for small firms (Cote, 1995).

Recent debate on the plausibility of win-win scenarios suggest that corporate environmental policies continue to be driven by compliance, rather than a genuine interest in minimising the environmental impacts of plant operations.

In LCCs there is very little incentive for industries to recognise the environmental impacts of their operations. The enforcement of pollution control legislation is very weak, and penalty for violation, low. The problem is compounded by the fact that in many LCCs interest in industrial waste issues among pressure groups such as labour unions and mass-based organisations is relatively recent. Most non-governmental organisations in LCCs have been and continue to be more concerned with rural resource management issues (Jain, 1995; Yap, 1990). Labour unions remain concerned primarily with job security and wage levels.

Financial: Perceived and Real
Because capacity in LWTs in a sense is an intangible asset, it is not likely to be given great value in the typical cost benefit analysis done by a firm considering investment options. This disinterest becomes justifiable where the LWT capacity is in the knowledge content of technology because then the expertise becomes “portable”. Where the cost of waste disposal or non-compliance is
insignificant, investment in LWT appears unnecessary. Where firms are already complying with government regulation using EOP technologies, the full cost of existing waste management practices is underestimated. Many of the costs are frequently lost or scattered in maintenance or operation ledgers (Yap, 1988). Small firms in particular, do not have the time or money. Recent work in Nova Scotia suggests that time may be the biggest impediment to change in small firms (Cote, 1995).

Most of the low waste strategies, i.e., good housekeeping practices, process modifications, materials substitution (see Introduction in this volume), involve post investment technical change. Developing in-house capacity therefore makes greater demands on industry. To be able to make the necessary incremental equipment or process changes over time, there must be mastery of the existing production/process technology. This “endogenous” capacity may be low. Risk capital is not readily available. The costs of accessing information on LWT, evaluation the different technical options, and/or adapting existing LWT can be significant. The costs are particularly onerous if not outright impossible to bear for small and medium-sized firms (Craemer et al., 1990; Yap, 1993).

Organisational/Informational
At the level of the firm, one of the major barriers to a full exploration of LWT opportunities lies in the fragmentation of production activities. Waste management is not seen as every plant employee’s business. There is also resistance to scrutiny by outside experts because of confidentiality concerns.

At the level of the industrial sector there is a lack of systematic, reliable and easily accessible source of information on the technical feasibility and financial opportunities of LWT. Firms who have successfully adapted low waste strategies are understandably unwilling to share information since LWTs give them cost advantage over their competition. This is particularly true for process modifications since they are not patentable. In LCCs concerns about corporate taxes further inhibit firms from officially acknowledging the profitability of low waste strategies.

Respect for the confidentiality concerns of industry has led to information dissemination materials such as brochures and pamphlets which are too general in nature. Because the application of technology is almost always location-specific, such publicity materials are rarely effective, except where the changes involved are good housekeeping and materials substitution. They are general but informative lessons.
The situation in LCCs is further complicated by the diversity of the major industrial waste generators in terms of scale, ownership and location of market. This implies different sets of constraints to technological innovations in each sector. The constraints will not be technical since proven LWTs exist for all these sectors although modifications may be needed in terms of scale and even design. These modifications demand endogenous capacity which is low in LCC institutions, whether government, industry or universities.

Export-oriented sectors such as textiles and electronics, are medium to large-scale operations. They are frequently controlled by foreign-based transnational corporations (TNCs) or as joint ventures, and are likely to enjoy a different policy regime than that for the domestic market such as metal finishing, foundry, and pulp and paper. The export-oriented sectors may resist any technological innovation on the ground that the additional costs will impact their international competitiveness.

Those producing for the domestic market differ in size. Metal-finishing firms are typically small family-owned operations, foundries are medium-scale, while pulp and paper manufacturing firms tend to be large operations. The financial and technical ability to innovate is virtually non-existent for the metal-finishing industry and minimal for the foundry. Technological innovations in the pulp and paper industry frequently require massive capital outlay as the experience in Canada shows (Yap, 1988), although they are proving necessary for competitiveness.

The study by Achtell (in this volume) of the institutional impediments to LWTs in India cites “bureaucratic dysfunction” and high administrative turnover as militating against effective transfer and sharing of information on LWTs among stakeholders (Achtell, 1995).

Systemic
A short and rigid compliance period, and requirements for “best practicable or available technology” – pervasive features of government pollution control policies under pressure from environmental groups – effectively favour the use of off-the-shelf, EOP technologies. A limited evaluation of the
success of the PRISMA Project (*vide supra*) in defusing “clean technologies” concluded that the focus on solving acute environmental problems led to a reactive, effect-oriented environmental policy. Industry inevitably chooses to implement off-the-shelf EOP solutions since they are more familiar and accessible. This incentive for EOP technologies is reinforced where subsidies provided for capital cost do not specify “clean technologies” (Craemer et al., 1990).

Weak enforcement and insignificant penalties, pervasive in most LCCs, reduce the cost to industry of non-compliance. The full cost of environmental degradation is thus not included in the cost of production.

Another systemic barrier to LWT is the strong vested interests of the environmental (waste management) industry in EOP approaches. Pollution control regulations have been developed around these technologies. The “environmental industry” is product-, not process-oriented. The search for and adoption of LWT involves a process of interaction between the firm and the “expert”. The environmental industry has invested heavily in developing technologies to “capture” and manage wastes. Many waste management firms have specialised in developing EOP technologies, i.e., wastewater treatment, industrial sewage treatment, engineered landfills, incinerators. When consulted by industry or government, they are likely to offer what they are familiar with and good at (Oldernburg and Hirschhorn, 1987). Given the pivotal role of the environmental industry to the diffusion of LWT, winning this industry over to LWT from their EOP thrust is crucial. Shifting from a volume-based to a value-based billing system for environmental consulting services, similar to Ford’s Total Fluids Management Unit Cost Billing Program (*vide supra*) may facilitate this “conversion”.

These barriers can be analysed in terms of the decision-making environment of the firm (see Figure 1.4 in the Introduction). What they tell us is that the “triggers” to the problem recognition phase are weak because of inconsistent, if not confused policy signals, weak enforcement of regulation, and weak or non-existent pressure groups from the community. The search activity of those firms who recognise that a problem exists is hampered by lack of information on feasible and cost-effective alternatives and financing.
CONCLUSIONS

Overcoming these barriers requires the participation of all stakeholders – government, industry, public interest groups, and consumers.

Attitudinal
A report on the LANDSKRONA Project observed that by first focusing on and demonstrating the technical feasibility of one or two key areas of production, corporate management becomes more receptive to the investment of time and resources to undertake a more comprehensive audit (Backman et al., 1989).

Education of consumers and environmental public interest groups is also needed. The education must be geared towards understanding not only of the seriousness of the industrial waste problem but also of the complexity of the search for effective and sustainable solutions. Environmentalists must be made to see that it is in the public interest not only that waste producers recognise the environmental problems their operations are creating, but also to be sympathetic to the firm’s search for cost-effective solutions. Stringent regulations, firm and short compliance periods are politically rewarding but have not proven effective or sustainable in the long-term.

The establishment of criteria for, and indicators of, “clean production” such as ISO 14000 and Eco-labelling is a step in the right direction but their overall effectiveness in reducing environmental degradation is likely to be limited. They may be a powerful incentive in international trade but have limited impact in terms of influencing consumer decisions in LCCs since these programmes presume a high level of mass education and effective demand to be truly effective in changing corporate behaviour.

Organisational/Informational
Databanks of case studies of successful LWT adoption are clearly necessary. The LANDSKRONA researchers conclude that the most valuable resource they offered to the firm is a compilation of detailed studies of successful LWT application (Backman et al., 1989). Industry-specific databases on LWT case studies such as that being developed in India should be expanded and disseminated. The database on LWT experts established by the United Nations Environment Programme should be systematically updated and expanded.
Financial

Subsidy for IWT Research and Development (R&D) is crucial in promoting the diffusion of these technologies, particularly for small- and medium-sized firms. Lessons from the OECD in this regard indicate that the application process and qualification criteria for such subsidy programmes must be simplified (Barnett, 1993; OECD, 1985; OECD, 1993).

Systemic

It has been suggested that the environmental industry could play more of a positive role if they could bill on a different basis, i.e., a certain percentage of savings from IWT introduced (Cote, 1995). The experience of Japan in promoting the “greening” of small and medium enterprises is relevant particularly to countries in the process of industrialising. Japan relied heavily on a combination of “carrots and sticks”. The most important lesson from the Japanese experience is that enforcement of environmental regulations is crucial in triggering industries to look for solutions. However it should not be overlooked that Japanese compliance deadlines allowed flexibility in the choice of technologies and the search for cost-effective strategies (ASEP Newsletter, 1994). Obviously forcing companies to pay the real cost of waste management and environmental degradation would go a long way in “triggering” problem recognition. This however may not be acceptable in the current political and economic climate.

REFERENCES


