Summer 8-31-1998

The feasibility of transferring clean technology from the United States to China : a case study from the paper industry

He Ning
New Jersey Institute of Technology

ABSTRACT

THE FEASIBILITY OF TRANSFERRING CLEAN TECHNOLOGY FROM THE UNITED STATES TO CHINA: A CASE STUDY FROM THE PAPER INDUSTRY

by
He Ning

In their pursuit of economic development, many developing countries are causing pollution at an alarming rate. One solution to the problem is the use of clean technology. Some developed countries have created various manufacture technologies which result in pollution prevention. There is a need for the transfer of clean technology from the developed countries to developing countries. It is beneficial to study the feasibility of such transfer.

The manufacturing processes of the paper industry are selected for this study. An investigation and comparison was conducted in order to evaluate the feasibility of clean technology transfer from the United States to China. The study found that it is technically simple but socially complex to transfer clean technology from U.S. industry to the Chinese counterpart.

THE FEASIBILITY OF TRANSFERRING CLEAN TECHNOLOGY FROM THE UNITED STATES TO CHINA: A CASE STUDY FROM THE PAPER INDUSTRY

by
He Ning

A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Environmental Policy Studies

Department of Humanities and Social Sciences

August 1998

APPROVAL PAGE

THE FEASIBILITY OF TRANSFERRING CLEAN TECHNOLOGY FROM THE UNITED STATES TO CHINA: A CASE STUDY FROM THE PAPER INDUSTRY

He Ning

Dr. Norbert Elliot, Thesis Advisor — Date
Professor and Chair, Department of Humanities and Social Sciences, NJIT

Dr. Daniel J. Watts, Committee Member — Date
Executive Director of Emission Reduction Research Center, NJIT

Dr. Sanford Bordman, Committee Member — Date
Professor of Economics, Department of Humanities and Social Sciences, NJIT

BIOGRAPHICAL SKETCH

Author: He Ning

Degree: Master of Science in Environmental Policy Studies

Date: August 1998

Undergraduate and Graduate Education:

- Master of Science in Environmental Policy Studies,
  New Jersey Institute of Technology, Newark, NJ, 1998

- Bachelor of Art in English Linguistics, minor in Railroad Engineering,
  Changsha Railroad University, Changsha, Hunan, China, 1976

Major: Environmental Policy Studies

Employment: Director, Technology Transfer Programs, Louis Berger International, Inc. East Orange, New Jersey

Presentations and Publications:

H. Ning, L.J. Pignataro and F. Zou,
"Articulation of Technology Transfer with Infrastructure Development,"
China Conference 1997. International Business with China: Opportunities and Challenges. Beijing, China, June 28, 1997.

This thesis is dedicated to
my mother, Xunliang Zhou

ACKNOWLEDGMENT

I would like to express my deepest appreciation to Dr. Norbert Elliot, who not only served as my thesis advisor, providing valuable resources and insight, but also gave me encouragement and confidence.

Special thanks also to Dr. Daniel Watts for his wealth of environmental knowledge and his active participation on my committee. Special thanks to Prof. Sanford Bordman for serving as a committee member.

I would like to express my sincere appreciation to Mr. William Reiley, Director for Environmental Division, Marcal Paper Mill, Mr. Sun Shujian and Mr. Liu Qi at Beijing No. 1 Paper Mill, and Dr. Duan Ning at China National Clean Production Center for their kindness and knowledge.

I would like tc thank my parents for their lifetime of encouragement and love. My sincere thanks also goes to my daughter for her understanding and support.

TABLE OF CONTENTS

TABLE OF CONTENTS
(CONTINUED)

LIST OF PHOTOGRAPHS

ABBREVIATION

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
ETAP	Environmental Technology Assessment Programme
NCPC	National Clean Production Center
NEPA	National Environmental Protection Agency
NGO	Non-Governmental Organization
SETC	State Economic and Trade Commission
SS	Suspended Solids
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industrial Development Organization
U.S.	The United States of America
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency

CHAPTER 1

INTRODUCTION

In *The World Bank Annual Report 1997* (On-line, 1997), the authors state that in developing countries "the successful economic development has taken a heavy toll on the environment, and 'brown environmental issues' such as air and water pollution are threatening health and sustainable development." Consider the Asian countries as an example. The rapid urbanization and industrialization in those countries are an engine for further economic development. These Asian countries have contributed, so far, to building up an increased capability for accommodating their rapidly growing populations in terms of employment opportunities and development of infrastructure and services. At the same time, however, such urbanization and industrialization have given rise to deleterious impacts on the health and sanitation of the region. For instance, the enormous consumption of energy resources in the industrial, transport, and residential sectors has already caused a negative impact on the global environment as seen in acid rain, global warming, desertification and other problems. It is thus essential that pragmatic measures for sustainable development be taken for industrialization in Asian countries to enable them to cope with their rapidly growing populations without adversely affecting the environment.

Is it possible to achieve healthy economic growth, which the developing world desperately needs, while maintaining a clean environment? What are the pragmatic measures to reach sustainable development?

Answers to those questions can be developed by examining the history of industrialization in developed countries. The developed countries attained their current status by sacrificing the environment in some ways during the past two centuries. Beginning in 1759 industrialization in the West went through the stages of industrial revolution, pollution, pollution control and, most recently, pollution prevention. Industrialization led to pollution, pollution led to pollution control, and pollution control evolved to pollution prevention. The developed countries started to adopt pollution prevention policies in the 1980s because pollution control became economically inefficient to achieve the desired levels of environmental protection. Therefore, environmentally sound technologies in various industries were born and implemented.

Environmentally sound technologies can also be called clean technologies because they emphasize the need to reduce or eliminate pollution at all stages of the production cycle. Some of the developing countries only became aware of the necessities of adopting clean technology at the Rio Earth Summit in June 1992. The Summit had clean technology transfer as an issue of paramount importance (Sharif, 1992). In order for the developing countries to reach sustainable development, they must have access to clean technology. Therefore, technology transfer from the developed countries to the developing countries becomes a necessity to facilitate the availability of appropriated technology.

There is no doubt that the developing countries are short of capital and technology to keep the environment clean while they are struggling to provide their people sufficient food, clothes and shelter. It is impossible for the governments of developing countries to

invest the same amount of resources as the governments and industries in the developed countries did to stay clean.

Transfer of clean technology is a much better concept than the traditional concept of technology transfer. It not only means selling and purchasing of know-how, blue prints, and equipment, but it also covers a much wider range of issues such as managerial and organizational issues. Therefore, it is not a simple technical fix but a comprehensive examination of all aspects of the process which relate to pollution. According to a survey of 500 U.S. firms, by improving house keeping, inventory systems and education of operators, the clean technology is a low cost or even a no-cost solution to pollution prevention (Husingh, 1989).

Policy issues are also significant elements for pollution prevention. When a government puts an appropriate policy in place, enterprises, research organizations, and even communities will be motivated and will creatively implement the concept. Social and cultural influences are also important factors in transferring of clean technology.

The paper industry has historically raised environmental concern. The industry's intensive water consumption and chemical processing cause water pollution. In response, the U.S. pulp and paper industry has created some viable clean technologies. The following study examines the feasibility of transferring existing U.S. clean technology in paper manufacturing to its Chinese counterpart manufacturers.

It is also important to recognize that this study has been conducted under "ceteris paribus" conditions or other factors remaining constant or given. For example, the political influence of certain mills may change, regional multipliers may become an important government consideration and the presently crucial "current account" goals of

the Chinese government may bring about other strategies for production. This study fully recognizes these implications but as any other research effort the scope has been clearly defined and explored within the confines of the "feasibility" objective.

CHAPTER 2

LITERATURE REVIEW

"Technology transfer is usually thought of as an imitative process. An underdeveloped nation imports the techniques and tools of more industrially advanced countries" (Kranzberg, 1966). Technology generally refers to equipment, facilities, license, design, skills or expertise. International technology transfer is a complex issue since it is not a simple selling of some machinery or a set of blue prints. It involves not only technology itself, but also at least two parties in two countries. Frequently these parties come from countries with different social, historical, and cultural backgrounds. These differences make the transfer process even more complicated (Harrison 1994).

The concept of technology transfer has been studied for decades. Much of the economic recovery of Europe and Japan after the Second World War reflects, in the broadest context, American technology transfer. But clean technology transfer is relatively new.

The term "clean technology" was first coined by the United Nations Environment Programme (UNEP) in 1989. Shortly after that, Agenda 21, the official document of the United Nations Conference on Environment and Development, stressed clean technologies as those which "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their waste and products and handle residual waste in a more acceptable manner than the technology for which they are substitutes." (Agenda 21, 1992).

This concept is also defined by US Environmental Protection Agency's (USEPA) Industrial Pollution Prevention Project as "the use of processes, practices, or products that reduce or eliminate the generation of pollutants" (USEPA 1992). It means that clean technology is to be thought of as the elimination of the sources of pollution through one or more of the following:

- Product reformulation,
- Process modification, or
- Improved housekeeping and management practices.

Where elimination of the pollution source is not possible, some form of recycling, (i.e., in-house, closed-system measures which return potential pollutants for reuse within a production process), may be regarded as clean technology. Therefore, clean technology can be grouped into two main categories: source reduction and on-site recycling. The concept of clean technology represents a paradigm shift (MacGarvin 1993). The traditional end-of-pipe pollution controls and treatment certainly reduced the damage of pollution. But these solutions come at increasing cost to both society and industries and have not always proven to be optimal. Cleaner technology, on the other hand, is a comprehensive, preventative approach to environmental protection. It requires people to be creative and to investigate all phases of manufacturing processes instead of trying to treat the pollutants at the end of the production process.

As Gro Brundtland, Prime Minister of Norway and Chairperson of the United Nations Conference on Environment and Development (UNCED), said in her opening speech at the UNCED, "Access to environmentally sound technologies is of critical importance in respect of every item of Agenda 21" (Westcott, 1992). Agenda 21 devoted

a full chapter, Chapter 34, to cooperation for the transfer of environmentally sound technologies and capacity building.

Traditional technology transfer emphasizes access to technology and the terms and conditions for its transfer. Time changes and the concept of technology transfer also changes. In recent years, especially in regards to clean technology transfer, the emphasis has come to include managerial, operational, and organizational skills as well.

The United States is one of the pioneers in clean technology. The Federal Pollution Prevention Act was signed into law in October 1990 (Federal Register, 1992). Since then, many incentive programs have come into effect: the 33/50 Program, the WasteWi$e Program, etc. These programs have one common goal: to encourage industries to reduce and eliminate pollution. US industries generally adopted clean technology with enthusiasm. In the past seven years, many industries, with the support of USEPA, created various approaches for pollution prevention (USEPA, 1995). The pulp and paper industry is one of them.

The pulp and paper making process is water-intensive: the industry is the largest industrial process water user in the U.S.(Factsheet, 1995). Bleaching processes, primarily used to whiten and brighten pulps for paper manufacture, may produce waste waters containing chlorinated compounds such as dioxin (Herman, 1993). The U.S. pulp and paper industry has creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts.

On the other side of the globe, China is experiencing an economic boom. Unfortunately the economic growth brings pollution problems. The pollution started in China's urban areas, and it is spreading rapidly into rural areas. In some parts of the

country, pollution is posing a direct threat to human health. However, the government is primarily at the stage of alerting people to pay attention to environmental protection (China Daily, Sep.24, 1996). Without sufficient legislation, regulations and enforcement to guide, control and support the fight against pollution, the situation in China will only get worse. The pollution generated in China will inevitably spread across the borders on land, in the air, and over the oceans.

In general, the current environmental protection effort in China is still concentrating on end-of-pipe control and treatment whereas the industries are reluctant to abide by the rules because they must absorb the high cost. Some industries are forced to close down (China Daily, Aug. 30, 1996). Introducing the concept of transferring clean technology is a potential solution to a complex problem.

Technology transfer activities usually were either funded by international organizations like the United Nations or through bilateral relationships to assist the developing countries' development, or they were initiated by transnational companies for commercial gains (Harrison, 1994). Clean technology transfer is a relatively new concept. So far it is mainly supported by international organizations such as the World Bank and United Nations organizations. The United Nations Environmental Programme (UNEP), the United Nations Development Programme (UNDP), and the United Nations Industrial Development Organization (UNIDO) have all played an active role. Some governmental agencies of developed countries are also successfully supporting clean technology transfer. A good example is the U.S. Agency for International Development's (USAID) Environmental Pollution Prevention Project in Tunisia (Nafti 1994). However, industry has not emerged in this arena as in traditional technology transfer. The industries are the

ones who created the technologies, and industry could and should be a major force for helping to keep the planet pollution free.

CHAPTER 3

OBJECTIVE

The pulp and paper industry has been an area of environmental concern. The industry's intensive energy and water consumption and chemical processing cause severe air and water pollution. Pulp making causes more air and water pollution than paper making. However, this study will only concentrate on the paper manufacturing process. There are two reasons to choose this section of the industry even though it is not the worst polluter. The first reason is the limited access to the industry data in China; the second reason is that the majority of the Chinese paper mills are small and medium sized enterprises. They are "endangered species" stranded by their limited financial capacity and limited access to information.

This study is aimed at analyzing the policy issues involved in a clean technology transfer between two mills in two countries with totally different social and cultural backgrounds. The technical issue in this case is only a very small portion of the problem. The real challenge lies in managerial, operational, policy, cultural and social factors

The objective is to prove, from the industry's point of view, if it is feasible to transfer U.S. clean technology in the paper industry to its counterpart in China. If it is feasible for one industry, it may be feasible for others. When clean technology transfer becomes a popular practice, the developing countries could reach their economic goals in an environmentally responsible manner.

CHAPTER 4

THE STUDY

4.1 Study Population

Although the majority of the paper manufacturing industry in China is small and medium sized paper mills, the small amount of pollution does accumulate to a threatening level. These paper mills have been informed by the government that they must decrease pollution before the year of 2000 or the mills would be forced to close (Sun, 1997). Such closures would result in thousands of people unemployed.

Another issue involved is financing. The international or bilateral efforts at clean technology tranfer are normally concentrated on large polluters, such as pulp making. There is hardly any funding left to assist the small and medium sized paper mills. Therefore, this study will concentrate on finding solutions for those small and medium sized mills which were left out on their own to comply with the environmental regulations.

The study population is two medium sized paper mills, one in the United States and one in China.

- The US mill has successfully adopted clean technology;
- The US mill is interested in sharing their success in clean technology;
- The Chinese mill is one of the central government owned factories so it is relatively well equipped, the workers are better trained, and the managers are better educated; and
- The Chinese mill is willing to adopt foreign clean technology.

4.2 Current Status of Paper Industry in the US and China

The following section describes the current status of the industry.

4.2.1 US Pulp and Paper Industry

According to *Profile of The Pulp and Paper Industry* (USEPA, 1995), the US pulp and paper industry consists of approximately 555 manufacturing pulp and paper mills. They are divided into three major categories: some mills produce pulp only (market pulp facilities), some only manufacture paper from purchased pulp (non-integrated facilities), and some mills produce the pulp used for paper manufacture on-site (integrated facilities). Of the estimated 555 pulp and paper facilities in the US, 55 are market pulp facilities, 300 are non-integrated facilities, and 200 are integrated facilities.

The US pulp and paper industry is a capital intensive sector with large facilities in terms of number of employees and chemical use. Almost three-quarters of US mills employ 100 people or more. The Bureau of the Census estimates that in 1992, 198,000 people were employed in pulp and paper mills with a payroll of $8.25 billion.

The geographic distribution of pulp and paper mills varies according to the type of mill. Pulp mills are located primarily in regions of the country where pulp trees are harvested from natural stands or tree farms: southeast, northwest, northeast and northern central regions. Paper mills, however, are more widely distributed.

The U.S. pulp and paper industry is recognized as a high-quality, high-volume, low-cost producer that benefits from a large consumer base, a modern technical infrastructure, adequate raw materials and a highly skilled labor force.

4.2.2 Chinese Pulp and Paper Industry

The pulp and paper industry in China produces 2.5 million tons of paper annually, which makes it the third largest paper producer in the world. According to 1996 national statistics, the industry consists of 11,025 mills (Sun, 1997). Among them, 130 mills have an annual output of 30,000 ton and the rest 5,000 tons or less. Therefore, the majority of the pulp and paper mills in China are small and medium sized. Most of the small mills are township or village owned mills.

Because of the shortage of timber, China imports large amounts of pulp from the U.S., Canada, Russia, and other countries. Other domestic sources for pulp are wheat straw, cotton stalk, and pre, or post-consumer recycled paper.

The mills are divided into two major categories: integrated facilities and paper-only mills. The integrated facilities are generally located adjacent to the raw material: timber or wheat/cotton stalk. These facilities are in the northeastern, southwestern provinces and Shandong province of China. The paper-only mills are mainly scattered in major cities, such as Beijing, Shanghai and Tianjin, where they are close to the market, or along the major rivers for the water supply.

The industry's waste water discharge is 18% of the total industrial waste water discharge, but its Chemical Oxygen Demand (COD) discharge is 40% of the total industrial discharge.

4.3 The Study Population

4.3.1. Description of the Paper Manufacturing Process

The paper manufacturing process adopted by the two factories is similar. The production process starts with processing the pulp. It includes pulp blending specific to the desired paper product, dispersion in water, beating and refining to add density and strength, and addition of any necessary wet additives. Wet additives are used to create paper products with special properties or to facilitate the paper making process. Wet additives include resins and waxes for water repellency, fillers such as clays, silica, talc, inorganic/organic dyes for coloring, and certain inorganic chemicals (calcium sulfate, zinc sulfide, and titanium dioxide) for improved texture, print quality, opacity, and brightness.

The processed pulp is converted into a paper product by means of a paper production machine. The pulp slurry is deposited on a moving wire belt that carries it through the first stages of the process. Water is removed by gravity, vacuum chambers, and vacuum rolls. This waste water is recycled to the slurry deposition step of the process due to its high fiber content. The continuous sheet is then pressed between a series of rollers to remove more water and compress the fibers.

After processing, the sheet enters a drying section, where the paper fibers begin to bond together as steam heated rollers compress the sheets. In the next process, the sheet is pressed between a stack of heavy rolls to reduce paper thickness and produce a smooth surface. Coatings can be applied to the paper at this point to improve gloss, color, printing detail, and brilliance. The paper product is then spooled for storage.

4.3.2 Marcal Paper Company

Marcal Paper Mills, Inc. is located in the northeast part of New Jersey, one of the most densely populated states. The Mill was established in 1930s and currently has approximately 1,000 employees, among which 80% are production staff and 20% management and administrative staff.

The Mill can be regarded as an environmentally friendly facility because it does not use any tree pulp but only recycled waste paper from municipal recycling programs and office waste paper as raw material for production. The recycled paper does not include corrugated or newsprint paper. The main products include bath and facial tissue, paper towels, and napkins.

The production process is a standard paper making process: the raw material which is recycled paper is repulped and then passes through a series of washing and screening stages before being reformed into tissue product. The roll stock is then converted into units packaged for retail and commercial sales.

The chemicals used in the production, such as caustic soda, non-elemental chlorine bleaching compounds and surfactants, are mostly absorbed in the product. Therefore, there are no toxic material in the discharged water.

4.3.3. Beijing Number 1 Paper Mill

The Mill is located in the northeast corner of downtown Beijing, the capital of the People's Republic of China. It is surrounded by residential buildings. When the Mill was established in the 1950s, it was surrounded by farmland in the suburbs of Beijing. The city

was urbanized at a surprisingly rapid speed, and by the 1980s, the farmland around the Mill was replaced by high-rise office and residential buildings and highways.

The Mill used to be an integrated mill with both pulp and paper manufacture. In the 1980s, the Mill was forced to stop the pulp making process because of the pollution. Currently the Mill is only making copy paper.

The production follows a rather standard paper making process. The following photographs illustrate the paper making process in the Mill. The process starts with moving the raw material to the production line. The Mill used two different types of raw materials. One is mixed hardwood virgin pulp imported from Russia or Canada as shown in Photograph 1.

Photograph 1. Raw Material: Imported Mixed Hardwood Pulp

The other type of material used is pre-consumer recycled paper as shown in Photograph 2. The material consists of the defective product and left-overs from the paper cutting machine. The raw materials are stored in crates and transported by a forklift from the storage area to the production line. The workers seen in Photograph 2 manually cut loose the binding bands and, with the help of the forklift, push the raw material onto the conveyor belt. The workers are not protected from either the forklift or the conveyor belt.

Photograph 2. Raw Material - Pre-Consumer Paper to be Recycled

The first step of paper making is to prepare the pulp. The virgin pulp or the recycled paper will be soaked in water and then beaten to separate the fibers. The tank in Photograph 3 is used to soak and agitate the raw materials.

Photograph 3. Preparing the Pulp - Dispersion in Water

Photograph 4. Adding Additives such as Talc and Silicas

With soaking and beating, the virgin pulp or recycled paper becomes a slurry. It consists of cellulose fiber and water. Chlorine, talc powder and silica are added into the slurry to ensure the whiteness, smoothness and brightness of the product (Photograph 4).

The slurry, with the desired blending, is moved via pipes into a huge rectangular container. On top of the container, there is a moving arm with a screen installed as shown in Photograph 5. In the container, the fiber will float to the top and the screen moves back and forth pushing the fiber to one side of the container as shown in Photograph 6.

Photograph 5. Screening

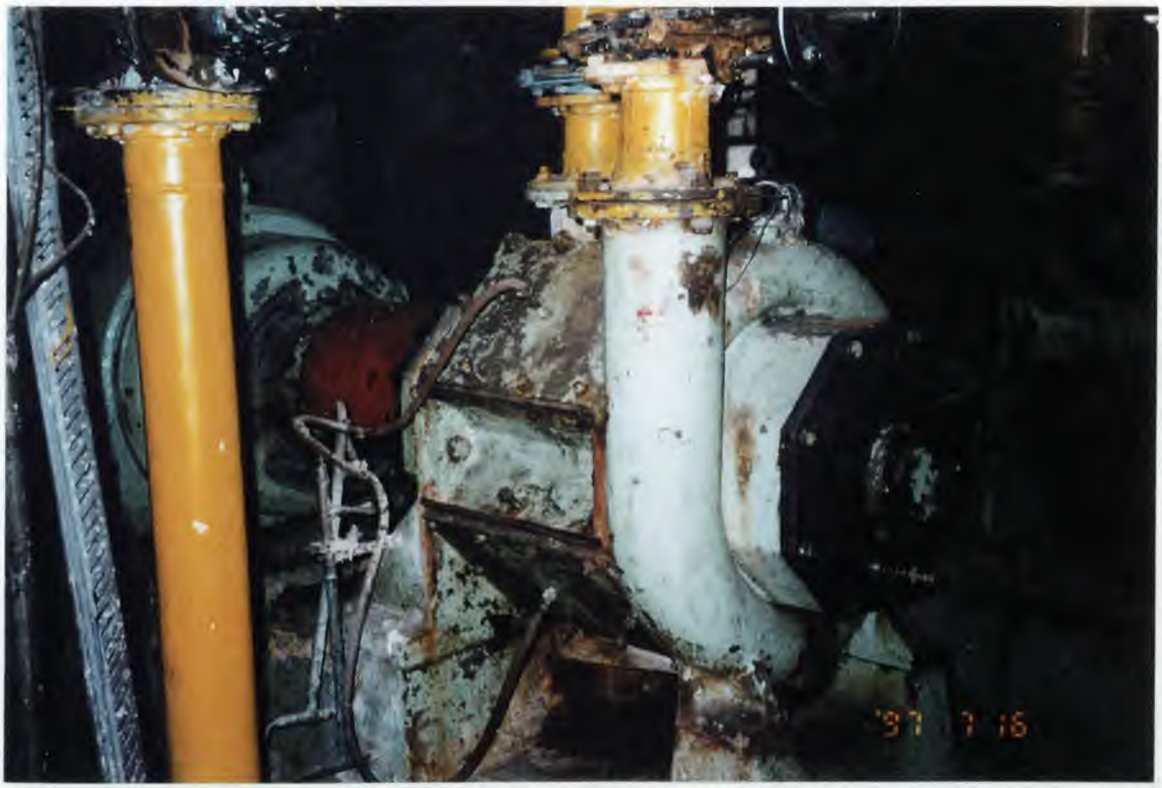
Photograph 6. Slurry before it is Transported to the Paper Machine

On the other side of the container, the excess water is discharged as shown in Photograph 7. This is where the Mill experiences problems meeting the environmental requirements. The discharged water contains high levels of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Suspended Solid (SS). The discharged water will be discussed further in Chapter 5.

Photograph 7. Discharged Water with High Levels of BOD, COD and SS

The slurry is transported through pumps and pipes to the next process stage. The paper manufacturing process can cause corrosion of equipment because of the chemicals used, hot water, and steam. The equipment needs well planned maintenance to make sure that it remains in good working condition.

The pump shown in Photograph 8 is covered with rust, and it certainly needs more attention. Poorly maintained equipment can often contribute to environmental problems because of reduced operating efficiency.



Photograph 8. A Pump Covered with Rust

Before the slurry goes into the paper machine, it is necessary to reduce the water content. A dewatering machine is shown in Photograph 9. There are some fibers shown at the edge of the dewatering machine. One result of adopting the concept of clean technology should be a reduction in the amount of those wasted fibers. The fibers could be recovered and recycled, or by modifying the machine or process, the loss of these fibers could be eliminated.

Photograph 9. Dewatering Machine

Photograph 10 shows the pipes between the dewatering machine and the paper making machine. As mentioned above, the paper making process can cause corrosion of equipment. These pipes are well protected by paint. Through these pipes, the slurry is transported to the next step, the paper machine.

Photograph 10. Transporting the Slurry to the Paper Machine

Photo 11 shows a traditional Fourdrinier Paper Machine. The slurry is evenly sprayed on to a wire-mesh conveyor belt. The conveyor carries the fibers towards a series of rollers. Water is removed by gravity.

Photograph 11. The Paper Machine with Wire-Mesh Conveyor Belt

A continuous sheet is pressed between the rollers to remove more water and compress the fibers as shown in Photograph 12 and Photograph 13 on the following pages.

Photograph 12. The Wire-Mesh Conveyor Belt as it Moves and Transports the Slurry between the Rollers

Photograph 13. The Continuous Sheet as it Moves between the Rollers

After pressing, the sheet enters a drying section shown in Photograph. 14. The paper fibers begin to bond together as steam heated rollers compress the sheet.

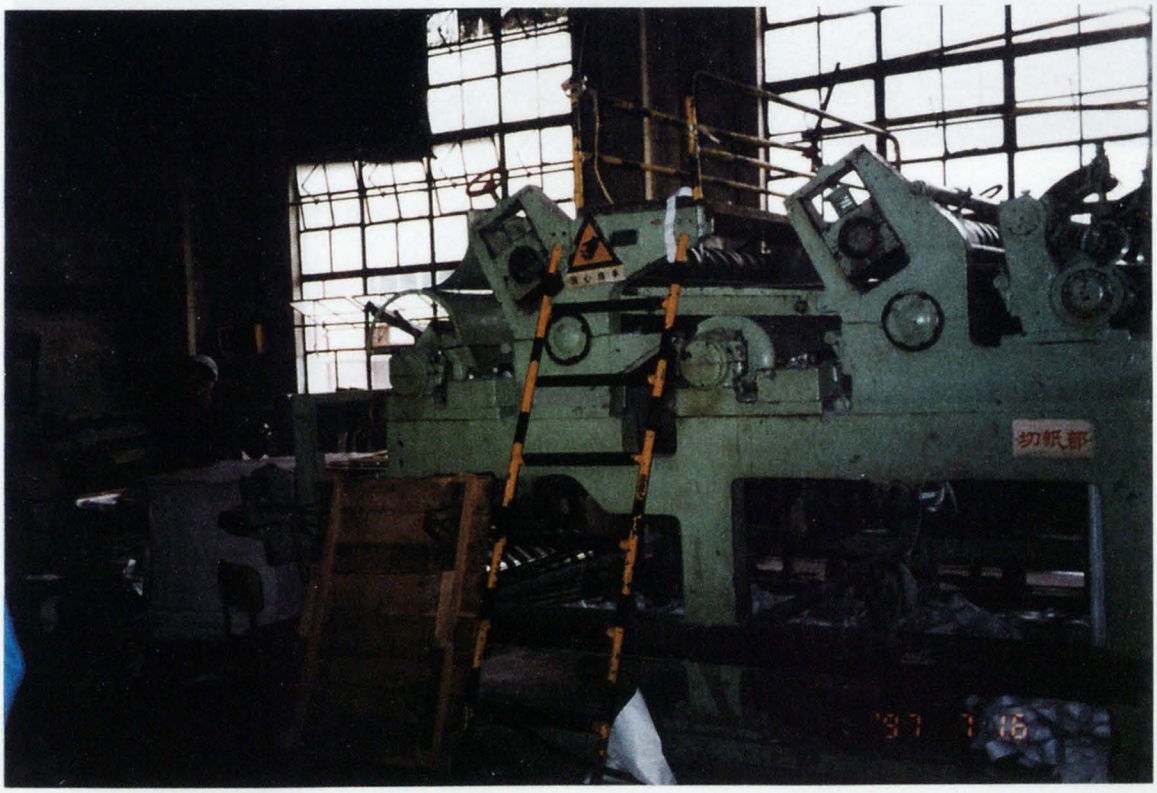
Photograph 14. Drying Process Through Use of Steam Heated Rollers

After the drying section, there is a series of heavy rollers where the sheet is pressed to reduce paper thickness and produce a smoother surface. The process is called the calender process. It should be noted that this machine is made in Germany.

Photograph 15. The Calender Process: Press to Reduce Paper Thickness and Produce a Smoother Surface

The paper product is then spooled as shown in Photograph 16.

Photograph 16. Spooling the Paper



Photograph 17. Paper Cutting Machine

The spool of paper is cut to size for shipment as shown in Photograph 17. Photograph 18 shows the paper crates ready for shipment.

Photograph 18. The Product is Ready for Shipping

Even though China has an extreme shortage of electricity and water, the Mill is enjoying its status as a key industry and the supply of water and electricity is almost guaranteed.

China has the largest population of all nations in the world. Therefore, it has a tremendous market for all sorts of paper products, copying paper is one of them. The products from the Mill enjoy a good reputation in Beijing and other parts of the country even though in recent years, they are facing competition from similar products produced in other provinces. Those products are sold at lower prices because some of the competing firms are not paying as much in environmental fees as the Mill.

The Mill employs more than one thousand workers. Fifty percent of them are directly involoved in production. The average worker receives good training. The Mill has its own technical school which is equivalent to a regular high school. The courses offered are not only the regular high school curriculum but also some practical courses to train the students for future jobs in the Mill. The top management of the Mill is composed of a combination of experienced veteran workers and young university educated professionals. They are very committed to the well-being of their employees and the mill. They are determined to adopt appropriate clean technology in order for the Mill to meet the new, more stringent environmental regulations.

Because of the educational level of the workers and the management and their past experience with digesting foreign technology (Photograph 15), it will not be too difficult to train the operators for some operational procedure changes. But clean technology transfer involves other factors, such as managerial, organizational or even cultural changes. These types of changes are totally new concepts. Incorporating these changes could present some difficulties.

In general, Beijing Number 1 Paper Mill is ready and eager to have access to clean technology. The management is fully committed to the change because it is well aware of the consequences if they do not clean up. The workers have sufficient educational background to be trained for new techniques or operating procedures. The Mill is in good financial standing because its product is in great demand. Furthermore, clean technology is expected to be less costly than end-of-pipe treatment. It does not require an importation of any complete set of equipment. Clean technology deals with the pollution problem from a different angle -- it solves the problems during the manufacturing process

by means of improving house-keeping, better inventory control and other managerial and operational adjustments. This approach certainly will not eliminate but reduce the amount of importation of hardware. With a good financial standing and a better problem solving approach, the Mill will be able to obtain funding to purchase the necessary clean technology.

CHAPTER 5

TECHNICAL ISSUES, POLICY ISSUES, CULTURAL INFLUENCES, AND SOCIAL INFLUENCES

Clean technology transfer is an extremely complex issue. Other than the technical factors affecting the transfer, there are several other variables which have direct impact on the transfer of clean technology. These include, but are not limited to, policy issues and social influences.

5.1 Technical Issues

The technical issues in clean technology transfer include not only "hardware" aspects such as the equipment, but also "software" aspects such as organizational and managerial issues. Clean technology transfer emphasizes "software" aspects because it is often more cost effective and easier to implement than end-of-pipe treatment.

Without a comprehensive environmental audit, it is difficult to accurately identify the problem areas potentially suitable for clean technology transfer. However, there are areas in Beijing Number 1 Paper Mill which obviously need improvement.

5.1.1 Evaluation and Recommendations for Beijing No. 1 Paper Mill

Agenda 21 emphasizes capacity building in developing countries. Capacity building is especially important in clean technology transfer because such transfer includes not only a traditional sense of technology transfer, (i.e. hardware) but also managerial, operational and organizational changes.

In the case of Beijing Number 1 Paper Mill, changes must be made in order to meet the environmental standard. Meanwhile, the Mill will be, as with any enterprise, facing a shortage of funding, especially hard currency, such as US dollars. Therefore, it is necessary to set priorities. It will be beneficial to start the changes with capacity building. With the operational, organizational and other adjustments in place, the size of the "technical fix" might be reduced to the minimum. The following adjustments are suggested and the sequence is important:

The most urgent problem for Beijing Number 1 paper Mill is how to reduce Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Suspended Solids (SS) levels in the discharge water. During the pulp preparation stage, cellulose fibers undergo changes in the water. They are separated and hydrated. Unfortunately not all fibers are fully captured in the paper making process because some fibers do not have sufficient time to float to the surface during the screening stage and some are too small to be retained by the paper mat. These fibers then remain in the discharge water and biological and chemical degradation occurs to the left-over fibers, consuming oxygen in water even when they are in streams, rivers or lakes. Such discharge water from paper mills is regarded as polluted water with high levels of BOD, COD and SS. Such contaminated water severely threatens the survival of fish and plants in streams, rivers and lakes by competing for the naturally occuring oxygen concentrations.

By comparing practices at Marcal Paper Mills, Inc. and Beijing Number 1 Paper Mill, some adjustments in house keeping and inventory control at Beijing Number 1 Paper Mill are appropriate. That could effectively reduce the fiber contents in the discharge water and thereby reduce the pollution level. Certain process modification is needed. The most important task is staff training which will facilitate the changes.

- *Staff Training*

Before any clean technology transfer occurs in a mill, environmental awareness has to become a part of the business and operating culture. The training of people is key to achieving this end. Training should be provided for all employees at all technical and managerial levels, focusing on continuously enhancing environmental awareness. Particular attention is needed at the management level where policies are set, as well as on the shop floor, where the actual production takes place.

Staff training is a crucial part of capacity building. This training will lay a foundation for clean technology transfer. An environmental awareness program is a necessity for every employee at managerial or shop level. When all employees understand that each person is responsible for clean production, the employees will be motivated to adopt the changes or create new and better housekeeping methods or better processes.

- *Improve House Keeping and Inventory Control*

Good house keeping relies not on changes in technology or material, but on human adaptability. With small changes in personnel practices, housekeeping and inventory control can have a great impact on clean production. Such changes have proven to be successful in the US mills and could be adopted at Beijing Number 1 Paper Mill. For example, the Mill can improve the storage area for the chemicals used in the production. Instead of leaving them loosely on the floor, the chemicals should be stored in containers (paper bags, boxes or barrels). This storage will reduce material lost, as well as keep the Mill clean and in better condition. This storage will result in lower cost by reducing loses of raw materials. Another obvious problem area is represented by Photograph 8. A pump is covered with rust. A better maintenance plan should be part of clean technology transfer.

- *Process Modification*

The key pollution issue in Beijing Number 1 Mill is the high level of BOD, COD and SS in the discharge water. Reuse and recycle can be a solution to the problem. Management should install a strainer or filtration unit to catch the secondary fibers and recycle them back into the paper making process. Alternatively, optimization of the screening step may result in greater utilization of the fibers. Reduction of the fiber content in the water will naturally will bring down the BOD, COD and SS levels. Another reuse and recycle concept is to recycle the water. Instead of discharging it, it should be recycled into the manufacture cycle. In order to prevent build-up of impurities, it may be necessary to implement only partial water recycle.

Such modifications will require further professional assessment since it could involve large amounts of capital. The proposed modifications must be carefully evaluated and then implemented. The goal of the effort should be to determine the source of the cellulose fibers being lost to the discharge water and to devise production improvements that will minimize these loses.

5.1.2 Implementation for Beijing No. 1 Paper Mill

- *Make Full Use of China National Clean Production Center*

China National Clean Production Center (CNCPC) is a pioneer in clean technology in China. Under guidance and assistance from UNEP and UNIDO, CNCPC has conducted environmental audits which assess the need for clean technology transfer and assist in determining possible solution. CNCPC also provided training courses for over 2,000

trainees in environmental auditing; more importantly CNCPC has the infrastructure to access foreign clean technologies existing in the public domain.

Beijing Number 1 Paper Mill should invite CNCPC to assist them in establishing an environmental awareness training program, to assist them in conducting an environmental assessment, and in identifying the necessary technology for clean production.

- *Exchange Visits*

Another suggestion on how and where to start clean technology transfer is to conduct an exchange program between the two mills. Each mill will send a study group to the counterpart's mill. Each group will consist of a manager, an environmental specialist and a representative of the workers, so that the investigation will be approached from different angles, from the managerial, engineering and workers level.

The Chinese group will observe how the US mill operates and what relevant technologies can be adopted. The US group will observe how the Chinese mill operates and make relevant suggestions after the observation. Such a study is a preliminary step toward clean technology transfer.

5.2 Policy Issues

Governmental policy is one of the major factors which affect the fate of clean technology transfer. It does not matter that the United States and China have totally different economic systems, government policy plays a decisive role in environmental protection in both countries.

5.2.1 US Federal Government Policies

The US system is, as Samuelson writes, " a mixed economy, which combines private

market with elements of government intervention"(Samuelson, 1998). Why does government intervene when there is a so-called free market economy? One reason for such intervention is that the market itself can not solve the problem of negative externalities, such as pollution. Therefore appropriate government policies are implemented to internalize the externality cost by putting a price tag on pollution. Pollution then can be dealt with in the market place. The government intervention can correct this particular market failure if the intervention is fairly and uniformly applied.

When the U.S. Congress began to pass environmental legislation in the early 1970s, it worked issue by issue, and often crisis by crisis. Incidents such as the Cuyahoga River fire, contamination of drinking water in New Orleans, and toxic contamination at Love Canal triggered the passage of the Clean Water Act, the Safe Drinking Water Act, and the Superfund Law, respectively. This symptom-by-symptom, crisis-by-crisis approach continued through the 1980s and early 1990s.

The benefits of this approach are indisputable. Over the past three decades, the U.S. has made great progress protecting human health and the environment by recycling, treating, and safely disposing of pollutants and waste. Rivers are no longer catching on fire. The sky is cleaner. U.S. environmental expertise and technology are in demand throughout the world.

But narrowly defined legislation -- the Clean Air Act dealing with air emissions, the Clean Water Act for water discharge and the Resource Conservation and Recovery Act for management of hazardous waste -- have some unintended consequences. By implementing these "command-and-control" and "end-of-pipe" style environmental laws and regulations, pollution was significantly reduced. However, there were several problems created.

- There are more than a dozen major national environmental laws on the books. When the industries implemented these thousands of thousands of pages of single-medium regulations, the implementation is confusing and even inconsistent.
- In order to respond to the environmental regulations, many businesses had to hire compliance specialists whose responsibilities are to deal with complex regulatory schemes. Normally these specialists had little interaction with product and process designers, production managers, and others at the core of the businesses.
- Compliance costs soared so high that it hindered economic growth.

As President George Bush pointed out in October 1990, "Environmental programs that focus on the end of the pipe or the top of the stack, on cleaning up after the damage is done, are no longer adequate. We need new policies, technologies, and processes that prevent or minimize pollution -- that stop it from being created in the first place." (Federal Register, 1990) It is under such circumstances the Pollution Prevention Act was signed into law on October 25, 1990.

The Pollution Prevention Act is a comprehensive law dealing with pollution from a different perspective. Instead of treating the pollution after it occurred, prevention means abating the generation of pollutants in the first place by changes in production processes such as modification of equipment or technology, reformulation or redesigning products, or substitution of less-toxic raw materials.

The Pollution Prevention Act designated the Environmental Protection Agency (EPA) to work in partnership with industry, government at the state and local level, and with communities. At the industry level, compliance with the Pollution Prevention Act required a concerted effort from not only the pollution prevention specialists but every

level of personnel in the industry (i.e., production managers, product and process designers, and production operators).

The Pollution Prevention Act represents a paradigm change. It certainly is not traditional "command-and-control" legislation. It changed the "end-of-pipe" pollution control solution to pollution prevention.

Is it a better solution to eliminate pollution? Is it industry friendly regulation? A survey of more than 500 companies which adopted cleaner production processes found that each company reduced industrial wastes by between 85% to 100%; even more importantly, the investment payback periods were only one month to three years. These types of benefits accrued to old industries as well as to high-technology industries. Some of the industries surveyed are listed in Table 1 (Huisingh, 1989).

A brief review of US environmental policy development reveals that there are different ways to curb negative externalities. There can be a command-and-control type of policy, "polluter pays", or commercial transactions of pollution permits.

The early US environmental policies were mainly of the command-and-control type. The government set up a standard, the producers, big or small, are required to meet the specific standard. These acts and regulations served the purpose well but not without problems, such as high compliance cost especially for small enterprises. Lessons learned in implementing command-and-control policies facilitated the evolution to other approaches. US environmental policies switched from end-of-pipe pollution control to pollution prevention, from command-and-control to more innovative approaches, such as the principle of "polluter pays" and trading of pollution permits. These policies resulted in more efficient environmental protection.

5.2.2 Chinese Environmental Legislation

Deng Xiaoping, the chief designer of China's reform, described his goal: to build a "socialist system with Chinese characteristics." That is, he wished to change the socialist, totally planned economy to a market economy. He also decided to leap from an agricultural economy to a modern industrialized economy. There was no existing model to follow. The model of the mainstream market economy in the US, West European countries, or even in Asia, Japan and Singapore did not apply to the Chinese situation. The Chinese government is experimenting with different approaches to achieve the goal. Disorganization in this transition is inevitable. Under such circumstances, authoritative governmental policies are the only practical way to keep control.

A classical example of inappropriable resources will illustrate the necessity of command-and-control type of government policy. Since the early 1980s many villagers along the Huai River, the third largest river in China, have built many small paper mills for badly needed cash. It was convenient for them to use the free water supply for the paper production and free discharge of the polluted wastewater with high contents of BOD and COD. These small paper mills caused horrifying pollution of the Huai River. People downstream lost their source of drinking water. There were no living organisms anymore in the River. The government had to intervene and closed down more than 300 such paper mills (China Daily, August 30, 1996).

Since 1978, China's economic reforms have progressively unleashed market forces and dramatically improved the material well-being of most Chinese citizens. The transition from a planned economy to a market economy has produced economic growth rates that put China among the world's fastest growing economies. Over the past nineteen years, rising incomes have eased poverty, reduced infant mortality, improved child and maternal

Table 1. Clean Technology Investment in the United States

Industry	Method	Reduction of Waste	Payback Period
Pharmaceutical Production	Water-based solvent replaced organic solvent	100%	less than 1 year
Equipment manufacture	Ultrafiltration	100% of solvent and oil; 98 % of paint	2 years
Farm equipment manufacture	Proprietary process	80% of sludge	2.5 years
Automotive manufacture	Pneumatic cleaning process replaced caustic process	100% of sludge	2 years
Micro-electronics	Vibratory cleaning replaced caustic process	100% of sludge	3 years
Organic chemicals production	Absorption, scrap condenser, conservation vent, floating roof	95% of cumene	1 month
Photographic film processing	Electrolytic recovery ion exchange	85% of developer; 95% of fixer, silver and solvent	less than 1 year

Source: Huisingh 1989

health, and lengthened life expectancy. During the same period, however, China's environment has deteriorated significantly. Rapid urbanization and industrialization have generated enormous volumes of air and water pollutants, lowering air and water quality. Over the years high levels of pollution have prompted the government to take corrective actions and expand environmental policies. These policies are listed below (Johnson, 1997):

- **1979** Environmental Protection Law (Trial) establishes a general legal framework for regulating environmental degradation.
- **1982** Marine Environmental Protection Law promulgated.
- **1983** Government declared environmental protection a basic national policy and formulated three policy principles for controlling pollution.
- **1984** Water Pollution Prevention and Control Law promulgated.
- **1987** Air Pollution Prevention and Control Law promulgated.
- **1989** Environmental Protection Law revised and formally promulgated, and eight environmental management programs endorsed.
- **1992** China, among the first nations to act on the Rio agenda, issued "Ten Strategic Policies for Development and the Environment."

  China Environmental Protection Action Plan formulated.
- **1994** State Council approved "China Agenda 21 -- White Paper on Population, Environment and Development".
- **1995** Amended Air Pollution Prevention and Control Law included tougher regulations for controlling sulfur dioxide.

  Solid Waste Pollution Prevention and Control Law promulgated.

- **1996** State Council approved "Ninth Five-Year Plan for Environmental Protection for 2010" with two supplemental documents "Total Emission Quantity Control Plan for Major Pollutants" and "Trans-century Green-engineering Plan."

  Amended Water Pollution Prevention and Control Law added provisions for controlling river basin pollution and imposes tougher regulations for protecting sources of drinking water.

  Government initiated a nationwide campaign to close heavily polluting township and village enterprises; to date more than 60,000 have been closed.
- **1997** Government announced that China will phase out leaded gasoline by 2000; implementation began in Beijing.

Since environmental regulations were first enacted in 1979, as shown above, China continued to improve its regulatory practices and to learn from the experiences of other countries. Current environmental legislation covers the management of waste water, solid waste, and atmospheric and noise pollution; the conservation of oceans and water courses; and the management and protection of forests, grasslands, soil, fisheries, mineral resources, water resources, wildlife, and coal and other energy resources.

In 1993, the Second National Conference on Industrial Pollution Prevention and Control, co-sponsored by China's National Environmental Protection Agency (NEPA) and the State Economic and Trade Commission (SETC), identified cleaner production as a major element in the country's strategy for prevention and control of industrial pollution, through the 1990s and into the 21st century. NEPA has promoted cleaner production through the implementation of a clean production project funded by the World Bank and involving pilot work in twenty-seven companies from different sectors of industry.

Chinese environmental protection legislation is at the command-and-control stage. It is necessary during this transition. It may appear to resemble early US environmental policies, but it serves different purposes. When Caldwell discussed environmental policies, he mentioned that "Most people appear to place health and survival above other considerations" (Caldwell,1990). The health and survival is the major purpose of Chinese environmental policies.

Even through command-and-control is necessary at this stage, it would be beneficial for the Chinese government to learn other approaches such as trading pollution permits and providing technical assistance to help enterprises instead of closing down them. Implementation of command-and-control in the U.S. was accomplished largely by specification of specific equipment or detailed treatment technology. An alternative approach that specifies pollution level goals and leaves the industry free to determine the best way to achieve the goal may be more appropriate for China.

5.2.3 The United Nations Policies

The United Nations advocates "sustainable developments" and is instrumental in facilitating transfer of clean technology. Agenda 21, adopted at the UNCI, has devoted a full chapter (Chapter 34) to the transfer of clean technology and capacity building.

UNCED emphasized sustainable development. " The availability of scientific and technological information and access to and transfer of environmentally sound technology are essential requirements for sustainable development" (Agenda 21, 1992). Such development requires the worldwide development and dissemination of technologies that are environmentally sound. Such development will only succeed through long-term partnership and cooperation between enterprises and government in a country, and more

importantly, between developed and developing countries. "There is a need for favorable access to and transfer of environmentally sound technologies, in particular to developing countries, through supportive measures that promote technology cooperation and that should enable transfer of necessary technological know-how as well as building up of economic, technical, and managerial capabilities for the efficient use and further development of transferred technology." (Agenda 21, 1992).

Two organizations in the United Nations took the lead to support the transfer of clean technology. The UNEP and the UNIDO jointly initiated the establishment of nine National Cleaner Production Centers (NCPC) in Brazil, China, the Czech Republic, India, Mexico, the Slovak Republic, Tanzania, Tunisia and Zimbabwe.

The objective of the NCPCs is to facilitate the transfer of cleaner technology from developed countries to industrial enterprises and environmental agencies in developing countries. This would allow them to incorporate cleaner technology and thus reduce industrial pollution. The activity profiles of The NCPCs were designed to cover four areas: in-plant demonstrations; training; information dissemination; and policy assessment.

These NCPCs have been in operation only a few years, but during this short time they have made an enormous impact through activities including demonstration projects, training, and creation of awareness.

In 1993, UNEP launched its Environmental Technology Assessment Programme (ETAP) as a complement to the Cleaner Production Programme. The ETAP encourages the use of technology assessment as a tool to support the development and application of cleaner technologies. It fostered information exchange on transfer of cleaner technology by publishing various documents on environmental technology assessment.

UNEP also worked with host countries to hold biannual international Cleaner Production Seminars since 1990. These seminars provided the international cleaner production community an opportunity to exchange their success and difficulties in institutionalizing the concept of cleaner production.

UNEP and other UN organizations served as the leader and supporter for transfer of cleaner technology. These UN organizations have built a new bridge between the developed and developing countries.

The United Nations brought the concept of clean technology to China and established the institutions to implement it. Clean technology transfer is an efficient tool for sustainable development. It encourages economic growth in an environmentally responsible manner.

5. 3 Cultural and Social Influences on Transfer of Clean Technology

The United States, a young nation, and China, an ancient country, have little in common. The difference in economic systems was discussed earlier in this chapter. It is also necessary to examine social and cultural aspects because of their potential impact on clean technology transfer.

5.3.1 Cultural Influences

Arnold Pacey wrote that "culture refers to values, ideas and creative activity" (Pacey, 1983). One's values and ideas are influenced by many factors such as one's economic status and governmental policies. Elliot defines cultural influences as "the way of life by which a society operates" (Elliot, 1997). A good example of cultural influences would be recycling in the U.S. One can learn about it by reading newspapers or magazines, listening

to radio or watching television. Messages urging people to recycle paper, glass, and cans can be found in a corporate office, throughout a community or even in a supermarket. The concept has been repeated frequently; it has been imprinted on the minds of people. Gradually the concept was socially accepted and it became common practice. The same concept may not applicable in the majority of locations in China. The Chinese people are still worrying about how to put enough food on the table and how to get sufficient living quarters for the family.

The Chinese society is based on family, no matter if it is under a feudalist or a socialist system. The majority of the Chinese population has always been peasants. The peasants live in a social structure centered on the family. Several families form a village. Very often one can find names such as "Village of Changs," or "Village of Wangs" in the map. In mid 1950s, the peasants were organized as People's Communes. Even these People's Communes are still based on the original villages of Changs or Wangs. Within these villages, people have very strong ties to one another.

As far as the rest of the population-- urban dwellers -- are concerned, the cities and the towns, in the early 1950s, were all organized into a huge network. Within this network, there are two parallel systems. One is called working units. Every person who is able to work belongs to one working unit. The other system is called neighborhood committees. This system is for housewives, retirees and handicapped people who do not have a regular job. In this network, every citizen belongs to one or the other system. In both the working unit system or the neighborhood committee system, people bond to each other to form a community. In China, no matter where one lives, people belong to a certain community.

Compared with the American individualism, the Chinese society is at a disadvantage as far as personal freedom is concerned. But it will be advantageous when this community network can be put to work toward environmental awareness/pollution prevention. Information can be efficiently disseminated through both the rural and urban systems. Implementation can also be carried out smoothly with the help of strong community ties and even peer pressure. The traditional Chinese cultural inflences could provide a positive impact on environmental protection.

5.3.2 Social Influences

Social influences are defined by Elliot as "those behaviors exhibited by a community. Living together as a community is what defines society, and it is the collective consciousness of the group that exhibits itself as a social influence" (Elliot, 1997). China has seen numerous changes in its more than 5,000 years history but in modern times, the most dramatic changes have occurred since 1978. Deng Xiaoping's "open door" policy started a totally new era. The country is in a transition period. The old socialist planned economy is phasing out, and a market economy is evolving. This transition triggered a chain reaction in social and cultural values for 1.2 billion people. Historically, being rich is an honor in the Chinese society. But under a socialist system, everyone is more or less equal. Nobody can get rich, but nobody is left out in hunger either. Everything is owned by the government. People were provided with the so-called "Iron Rice Bowl," meaning that the government guaranteed every worker a lifelong job. Even the farmers did not need to worry if there was a drought or flood. The government would always help them.

However, there is no incentive to work harder or produce more. When the economic reform started in the late 1970s, the government first initiated an experiment in

Shenzhen, a village in Southern China. As Deng Xiaoping indicated, the experiment was to "allow some people to get rich first." This experiment was like a thunder blast and woke up the country. People realized that the opportunity existed. Naturally, they became more creative and dynamic. People's value system started to change. The change nevertheless had its negative effect. During this transition period, economic growth or "getting rich" has been the "collective consciousness" and the "way of life". It definitely brought some undesirable consequences, and severe pollution is one of them.

The government realized the problem early . Only one year after the "Open Door" policy was adopted, the Environmental Protection Law was issued in 1979. Since then, many other rules and regulations were established to curb the environmental deterioration. However, these legal documents have not been closely connected to the people's value system. On one hand, the government has hundreds of pages of environmental protection legal documents, but on the other hand, the masses still maintain "getting rich" as the first priority, environment problems are not yet part of the public consensus. To change the situation, or otherwise change people's "values and ideas" requires long-term, wide-spread multimedia environmental education programs in order to correlate the government policies with every citizen's value.

The vast cultural and social differences between the U.S. and China will not form any barriers for clean technology transfer because such transfer is in favor of economic growth. It can be regarded as a healthier way of helping people getting rich or a tool for sustainable development.

CHAPTER 6

CONCLUSION

This case study was conducted over a relatively short period of time. Nevertheless, it is not difficult to reach the conclusion that it is feasible to transfer clean technology from the US to China based on the study findings. However, to successfully transfer clean technology, conditions must be met, including government policy support, public awareness and limited importation. These conditions are further explained in Section 6.4.

6.1 The Potential of Transferring Clean Technology from the US to China

In general, there is a future for clean technology transfer between the US and China. The reasons are discussed below.

6.1.1 Global Trends

Peoples in both developed and developing countries, including the U.S. and China, are more and more aware of the horrifying consequences of past careless economic development. The air and water are polluted. The rain forest is disappearing. Around the world, governments are working on environmental policies, many research institutes are looking for new cures to environmental problems and thousands of grass-root Non-Governmental Organizations (NGOs) are educating the people. This awareness has created a global trend toward improved development practices.

The UNCED played a crucial role in identifying clean technology transfer as one of the solutions to global environmental problems. The UN organizations also took action in

supporting clean technology transfer. The establishment of National Clean Production Centers in nine countries on three continents is a good example. It is well-spent "seed money." With the technical guidance and financial support of UNEP and UNIDO, China established its first National Clean Production Center.

There is also strong bilateral support from some developed country governments This global emphasis is helpful for clean technology transfer because it may result in generating more technical opportunities for transfer and making the technologies more available.

6.1.2 The US Industries Possess the Clean Technology

Due to the combined efforts of government and industries during the past eight years, US industries have developed various clean technologies. These technologies would be available if the commercial terms and conditions are appropriate.

6.1.3 China Has the Foundation to Receive New Technology

First of all, China has a relatively stable political situation which is very important to the foreign parties involved in international technology transfer. Secondly, China has showed the world community that it has the ability to manage its economy. The last but the most important factor is that industries (i.e., management and workers) are willing and have the technical capability to adopt and utilize new, clean technology.

6.2 The Barriers for Clean Technology Transfer

Clean technology transfer is a relatively new concept. It faces many challenges.

6.2.1. Lack of Funding

The shortage of funds is nothing new but traditional and universal. No matter how much funding multilateral or bilateral agencies invest in clean technology transfer, it would be minimal compared with the demand. Regarding the subject of the present study -- the pulp and paper industry in China -- there are 11,025 factories. Who would have sufficient funds to support all of them to clean up? There will never be sufficient financial support from public funding.

6.2.2 Lack of Policy Support

Although the Chinese government established various environmental acts and regulations, two problems exist. First, these acts and regulations are of the command-and-control type. They can hardly motivate industries to stay clean. Second, the existing policies normally put small and medium sized enterprises at a disadvantage.

6.2.3 Lack of Access to Technology

The industries in the US or other developed countries have the clean technology readily available but the Chinese industries have no idea what is available because they have no means to get to the sources. An average Chinese factory has no access to Internet, no access to any foreign industrial associations, no access to any trade publications. In short, there is a lack of infrastructure to access the available clean technology.

6.3 Recommendations

Both the U.S. and Chinese governments and industries have put in tremendous amounts of effort to create a better environment. However, there are some areas which can be improved. The following recommendations are based on the findings of this study.

6.3.1 "User-Friendly" Policies

Since 1979, the Chinese government has issued a number of environmental related Acts and Regulations. Compared with the US pollution prevention regulations, most of the Chinese environmental regulations are still of the command-and-control type. While this approach may be necessary under the current situation, it is strongly suggested that the government considers establishing some "user-friendly" and incentive attractive regulations to encourage industries to stay clean. Pollution prevention and clean technology transfer should be part of national environmental protection legislation. The government should work with industries and provide necessary technical assistance to industries. When compliance with pollution prevention requirements costs less than pollution control, the industry will accept it.

China is currently undergoing a historical transition from a planned economy to a market economy, similar to many Eastern European countries. It is an extremely sensitive situation. This economic transformation inevitably results in downsizing of those government subsidized enterprises. Furthermore, the tough pollution control regulations could force hundreds of polluting factories to close down. This would unquestionably result in thousands of people becoming unemployed. It will definitely lead to certain social unrest.

The critical issue is how to keep the balance between clean environment and healthy economic growth. Clean technology can be very helpful to maintain the balance. It doesn't require a large amount of investment but it examines every factor of the production process attempting to clean up each step as the production proceeds. In the US, there are existing clean technologies in almost every industry. Clean technology transfer could be of great assistance to the Chinese government or other developing countries which are experiencing an economic transition.

The US government has been active in assisting other countries in adopting clean technology, but there is a limitation for such funding. Instead of continuously increasing the international aid funding, the Chinese government should establish policies to encourage US industries and research organizations to export their clean technologies through commercial transactions. It will be a win-win situation: it will be beneficial for exporting industries and for the global environment.

6.3.2 Public Awareness

Public awareness plays an important role in the success of clean technology transfer. It is very important in two ways. First, the public awareness can be translated into pressure for the polluters to clean up. Second, public awareness means that average workers in a paper mill understand their own role in keeping the environment clean, and they will be motivated and be creative in implementing clean technology at work.

Comparing the public awareness in the US and in China, one can find a huge gap. Because of the combination of governmental policy, media information, and various educational programs, the US public is well aware of the importance of clean

environment. On the other hand, the Chinese public has not had sufficient exposure to such issues. Therefore, it is necessary to improve the situation. The public awareness programs can be implemented through organized seminars, media coverage (newspaper, magazine, radio and TV), community programs and school systems.

6.3.3 Limited Importation of Hardware

As mentioned earlier, shortage of funding is a universal problem. It certainly applies to clean technology transfer. How to make the transfer possible? The China National Clean Production Center (CNCPC) is an important part of the solution.

National Clean Production Center (NCPC) is a wonderful initiative. These Centers are essential to the success of transferring clean technology. They serve as the bridge between the clean technology in the developed countries (sometimes in other developing countries) and the industries in the developing countries.

In the case of transferring US clean technology in the paper industry to China, the CNCPC can serve three functions in order to reduce the cost of clean technology transfer. First, CNCPC can assist Beijing Number 1 Paper Mill to identify what needs to be done, including the "technical fix," operating procedure changes and house keeping improvement. Second, CNCPC can undertake delivery of training to develop staff capability to adopt the new operating procedures or new housekeeping methods and other human related issues. The third function of CNCPC is to serve as an information clearing house. Since it is much better equipped and trained than Beijing No. 1 Paper Mill, it can assist the Mill to identify and evaluate the appropriate technologies to transfer. These appropriate technologies can be either domestic or American. All these activities are

aimed at minimizing the importation and keeping down the cost so that the clean technology transfer will become feasible within a limited budget.

6.4 Conclusion

In developed countries, pollution prevention proves to be better than pollution control. Those clean technologies will no doubt be helpful for developing countries in the pursuit of the same goals.

Clean technology is not only using a particular technology to solve a specific pollution problem. It is a paradigm shift, from pollution control to pollution prevention; it is a comprehensive approach to reduce pollution; it involves greater human efforts while using some purely technical solutions. Therefore, it is evident that such transfer needs more policy support.

In conclusion, the study evaluated and determined that it is feasible to transfer clean technology from the US paper industry to their counterparts in China with the support of government policies and public awareness. With these conditions in place, clean technology transfer can apply to any industry. More importantly, this case study revealed the necessity of such transfer. Clean technology transfer would assist small and medium sized enterprises in any given industry in China, to maintain their production under the ever stringent environmental regulations. This transfer will result in healthy economic growth and social stability which are essential to developing countries, especially those countries experiencing economic transition such as in China.

It is the author's hope that this case study will be pursued by the policy makers, especially in China to increase their awareness of the significance of clean technology transfer and, thereby, encourage them to provide necessary support.

REFERENCES

Agenda 21, The United Nations Programme of Action from Rio. (1992). New York, United Nations Department of Publications.

L. K. Caldwell. (1990). *Between Two Worlds, Science, The Environmental Movement and Policy Choice.* Cambridge University Press, New York, 1990

Cleaner Production Worldwide (1993). Paris, United Nations Environment Programme.

N. Elliot and N.Coppola et al.(1997). *Environmental Protection, Solving environmental Problems from Social Science and Humanities Perspectives.* Kendall/Hunt Publishing Company, 1997

Environmentally Sound Technology for Sustainable Development. ATAS Bulletin No.7. United Nations

Fact Sheets: Paper Industry. Pollution Prevention Information Center, USEPA

S. Georg. (1993). Clean technology - Innovation and environmental regulation. *Environmental Professional*, 15, pp. 533-550

A. Harrison. (1994). The role of multinationals in economic development: the benefits of FDI. *Columbia Journal of World Business*, 29, pp. 6-11.

S. A. Herman. (1993). *Handbook on Pollution Prevention Opportunities for Bleached Kraft Pulp and Paper Mills.* USEPA.

D. Huisingh. (1989). Clean technologies through process modifications, materials substitutions and ecologically based ethical values. *Industry and Environment.* 12, pp. 1- 25

T. M. Johnson. et al (1997). *China 2020, Clean Water, Blue Skies.* The World Bank , Washington DC. pp.7

M. S. Kasman. (1992) Economic and legal barriers to the transfer of environmental sound technologies to developing countries. *Advanced Technology Assessment System.* Issue 7, pp.162-169

M. Kranzberg. (1966). The transfer of technology : Retrospect and Prospect, Joint Session, *Air Force Office of Science Research* No. 67-008, Washington D.C.

M. MacGarvin. (1993). On precaution, clean production & paradigm shifts. *Water Science & Technology*, 27, pp.469-480.

Model Pollution Prevention Plan for Kraft Segment of the Pulp and Paper Industry. (1992). Washington D.C. USEPA

R. Nafti. (1994). The environmental pollution prevention project (EP3) in Tunisia. *Industrial Environment*, 17, pp.55-57.

Profile of the Pulp and Paper Industry (1995) Washington D.C. USEPA

A. Pacey. (1983). *The Culture of Technology*. The MIT Press. Cambridge, Massachusetts. pp. 5.

P. A. Samuelson and W. D. Nordhaus. *Economics*, Irwin McGraw-Hill, 1998

N. Sharif. (1992). Technological dimensions of international cooperation and sustainable development. *Technological Forecasting & Social Change*, 42, pp.367-383.

J. S. Sun. (July 16, 1997). Personal Interview, Beijing, China

W. F. Wescott 2nd. (1992). Environmental technology cooperation; a quid pro quo for transnational corporations and developing countries. *Columbia Journal of World Business*, 27, pp.144-153.

The World Bank Annual Report 1997. (1998). [on-line]. Available http://www.worldbank.org/html/extpb/annrep97/htm

B. Xin. (September 24, 1996). Environmental key to sustaining economic progress. *China Daily* pp. 2

Xinhua. (August 30, 1996). Un-polluting the Huihe River. *China Daily* pp.3