

CREATING ENVIRONMENTAL VALUE IN TAIWAN:

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Executive Summary

In the 21st Century, Taiwan will encounter further environmental challenges at the local, regional and international levels. Post-Kyoto concerns for climate change will create international pressures to reduce green house gases (carbon dioxide, methane). **The environment and energy** are important domestic and international issues that **are now national security concerns for Taiwan**.

The strategic plan is offered for transforming the Taiwan Environmental Protection Agency (TEPA) to an organization that spearheads the government's effort to create a sustainable future. As the "environment" is defined as energy and material flows in commerce, not just waste, it must be brought to a central function in government. Therefore, we recommend the **formation of a Ministry for Environment and Resources**. However, it is critical that **resources** explicitly include responsibilities to affect energy and materials utilized in construction, agriculture, transportation and industry.

Espousing a sustainable future for Taiwan creates the opportunity to define **environmental value**. Creating environmental value can be a unifying function for leaders in all sectors of Taiwanese society to link their social and economic interests.

Government needs to apply a new modality to its environmental management programs. While strict enforcement at all levels of governance establishes integrity, a new modality uses **public persuasion and cooperative negotiations** with industrial sectors. Management personnel will need to enhance their skills in environmental risk assessment, economic impact assessment, and environmental negotiation to be ready to implement a new government-industry-citizen partnership era. **Environmental education** continues to be a critical factor shaping public attitudes and behavior as well as cultivating the next generation of professionals. Urgently needed are required **environmental ethic and economic courses in business and engineering schools** in Taiwan. Educational programs including the environment, energy and workers health cost accounting, life-cycle analysis, industrial ecological design, and pollution prevention as well as ecological philosophy are crucial for Taiwan in a competitive trading world.

The TEPA should develop a strategic plan based on sustainable concepts in transportation, construction (housing, buildings, and infrastructure), agriculture, and industries.

Concerns about carbon dioxide emissions can provide incentives for ecological industrial policy. **The TEPA should promote ecological efficiencies through several actions** that include: expanding government-funded building research programs, encouraging ISO 14000 compliance, developing model specification and codes for industrial parks, building materials, and ventilation rates.

In the near term, **the TEPA should include exposure and health risk reductions together with the pollution stress index (PSI) as measures of program performance.** Health risks and exposure indices are more meaningful for guiding research, control programs and communication with citizens. Applying such matrices reveals ozone and particulate air pollution to be serious concerns. **A research center for risk assessment should be established** to assist, systematically, in implementing TEPA's risk-based environmental policies.

TEPA would benefit from creating a core function for life-cycle analysis, economic and policy evaluation and multi-sector environmental and energy linkages.

In the long term, **TEPA should promote the establishment of a research center that will provide the scientific and economic support for the sustainable development of Taiwan.** International participation of advisors or collaborators would encourage rapid transfer of ideas and training of research staff. Through a center for a sustainable Taiwan, eco-innovation for Taiwan's construction, agriculture, transportation, and manufacturing can be promoted. The center should receive broad-based support from all ministries.

TEPA should change its current practices for handling air pollution research. TEPA should ask the NSC to increase their manpower in managing the TEPA research fund or TEPA should return to managing this fund itself. All research projects should be multi-year funded and with clear outcome applications.

For a "sustainable Taiwan" there needs to be philosophical grounding in cultural norms and religious principles. The TEPA can advance broad-based participation among cultural, religious, social, political and economic leaders towards defining "ecology" in the context of Chinese and Western culture.

Letter to the Administrator

May 28, 1998

Dr. Hsung-Hsiung Tsai, Administrator
Environmental Protection Agency, Taiwan ROC
Taipei, Taiwan

Dear Administrator Tsai,

We believe the Taiwan Environmental Protection Agency (TEPA) is at an inflection point. There is growing appreciation, nationally and internationally, of the connection between human activities, primarily through energy consumption and environmental damage, and changes of consequential importance. Increasingly, members of Taiwanese society are realizing that the current version of modern Western/Chinese culture is not completely satisfying. Nature, long absent as an important balance in an increasingly developed world, is now recognized as integral to health—physiologically and spiritually.

Symbolism is important: the Executive Yuan can elevate the TEPA to include its Administrator in the Ministry or Cabinet. This act will make the environment as prominent as military and economic security. Substantial changes in how Taiwan proceeds with environmental enhancement depends on national understanding and support for new modalities of environmental management. Improvements depend on how effectively the TEPA articulates the relationship between individual, corporate and government behavior to the environment through all aspects of human endeavors.

Included in our report are many specific recommendations. Several call for a new contextual relationship for the TEPA, both with government and with the regulated and public community. Programs are needed to enhance the policy/economic analysis capacity within the TEPA. Research on ozone, particles, and acid, metals, sulfate and nitrate deposition should be designed to reveal the contributions of both domestic and international sources. Energy conservation strategies should be linked to pollution prevention in a series of national policies that target industry, commercial/retail business, agriculture, construction companies, and many publicly funded institutions. Ecological design should be promoted with government-funded programs and incentives for industries. Besides these and many other specific recommendations, the TEPA should facilitate forums for discussions about the philosophical basis for protecting nature within a Chinese cultural context.

We thank you for the intellectually stimulating opportunity of working on this project and the time you and others kindly spent with us.

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1. Charge

In September 1997, Dr. Hsung-Hsiung Tsai, the Administrator of Environmental Protection Agency, Taiwan ROC requested that Dr. Chang-Chuan Chan undertake an evaluation of the Taiwan Environmental Protection Agency's (TEPA) air quality research and control programs, funded under the Air Pollution Fee system. The Air Pollution Fee policy was established under the Air Pollution Control Act Amendments in 1992 and implemented in 1995 with levies mainly on sulfur (S) content of fuels (coal, fuel oil, petroleum coke, diesel) and lead (Pb) in gasoline. The Air Pollution Fees have now been expanded for construction works, which emit total suspended particulate (TSP). In a second phase (July 1998), fees will be assessed for NO_x stack emissions.

By two indicators, money raised and the Pollution Stress Index (PSI), one might conclude that the Air Pollution Fee policy has been successful. Expanding the program to stack emissions is designed to give sources incentives to switch to even cleaner fuels or install abatement equipment. The Air Pollution Fee policy has not been without its critics. Some argue on ideological grounds that "charging to pollute" is an anathema to air as a public good. Setting the correct fee to incorporate externalities such as health and ecological damage is imprecise. If the fee is too high, it distorts the market and places Taiwanese products at a disadvantage. If the fee is too low, then sources will adsorb the cost and continue to pollute. There are other practical considerations about effective fund management when revenues for the Agency effectively double.

The charge to Dr. Chang-Chuan Chan was initially to appraise the Agency about air pollution research and control programs. In preliminary discussion with Harvard faculty, project consultants and associates at the Academia Sinica, a more comprehensive scope was developed. We evaluated air pollution data to determine temporal and spatial trends that inform about both the progress and the effectiveness of abatement strategies. With the status and trends of air pollution in Taiwan as a starting point, a review of the health effects literature revealed serious concerns for fine particulate matter and ozone.

It was clear to us that Taiwan's long-term air quality is not secure. Strategies that addressed the complex distribution of sources and integrated many sectors of society in schemes to reduce and prevent pollution are needed. The report presents a rationale for linking Taiwan's social, economic and political interests to environmental quality of life concepts. The timing may indeed be right as the national energy policy debate has a renewed sense of urgency in the post-Kyoto era for global environmental issues. Taiwan's political, academic, economic, and religious leaders need to recognize the extraordinary shift in attitudes about environmental judgement, about civic behavior of corporations and government.

The TEPA, along with many respected public and private organizations in Taiwan, need to articulate the moral imperative of a healthy environment for sustained prosperity. With initiatives and incentives, public institutions can provide opportunities to create a more equitable economy by reducing waste, increasing energy efficiency, and stimulating innovation within industry, academics and public agencies. All sectors of Taiwan's economy must contribute to resolving energy and environmental concerns. Independently, Taiwan can ascribe its goals for water, soil and air quality and can begin to lead other Southeast Asian nations by the persuasive force of example.

2. Structure of the Report

The main text of this report is organized in seven major sections. First, we review the TEPA's current system in managing environmental protection programs in general, and then we specifically focus on air pollution controls. By such critiques, we are able to identify areas of improvements for TEPA. Second, we make arguments on why this is an excellent critical time for Taiwan to rethink its environmental strategies. We argue that current and future social, political, economic and cultural developments both internationally and domestically compel Taiwan to act on re-thinking its environmental strategies in order to meet the challenges in the next century.

Third, we describe our strategic planning process. The principles, methodologies, and activities of developing a strategic plan for an agency from an outsider's viewpoint is worthwhile. Since this is the first time people outside the TEPA have charted a strategic plan, the scheme of our strategic planning process may be useful for future reference. However, due to financial and time limitations, our strategic plan is mainly based on document reviews, data analysis, and interviews with governmental officials and academic people. We were unable to include citizen's participation and feasibility analysis in creating this report. We do recommend that the TEPA continue to carry out these activities once the strategic plan has been adopted this year.

Fourth, the major findings of data analysis are presented in a separate section in order to demonstrate the severity of urban air pollution in Taiwan and the need for new control strategies. Detailed results of air quality analysis are in Appendix A. Finally, the fifth, sixth and seventh sections describe concrete recommendations of our strategic plan for the TEPA, which include plans for environmental controls in general, air pollution controls in specific, and air pollution research. The essence and key conclusions of our interviews and workshops have been incorporated into our strategic plan; detailed information on these activities is in Appendix B of this report. Appendix C has two sections, C1 and C2. Section C1 presents a long-range transport model of acid rain precursors from China. Section C2 is an historic review of NO_x control in Japan. Appendix D is the executive findings of the US National Research Council for

airborne particulate matter. These recommendations will also be useful to the TEPA as it considers its particle research agenda.

3. The Current System: Areas Needing Improvement

Although the TEPA has made some progress on air pollution controls in the past, our reviews indicated that TEPA's policies of managing air quality can be improved by addressing institutional shortcomings in the following areas.

Environmental Regulations

According to a multi-national survey on the perceptions of environmental regulations, as reported by Panayotou and Vincent (1997), "Taiwanese business leaders view TEPA's rules and regulations as more inflexible and less transparent than environmental practices of almost all other nations." Factors actually contributing to the apparent inflexibility and lack of transparency of environmental regulations are somewhat difficult to describe. A naïve business community almost always views environmental concerns in opposition to economic interests. Compliance with environmental regulation is interpreted as a decrease in competitiveness. The fact that 95% of Taiwanese businesses are small, employing 150 persons or less, contributes to a cynical view of the TEPA. Many smaller firms do not have the personnel to respond to the often frequent and confusing requirements of the agency. Unconvinced by the legitimacy for environmental regulations and receiving conflicting signals from different governmental agencies, the Taiwan business community finds it difficult to recognize links between environmental protection and competitiveness. Changing the paradigm is critical to TEPA's future success.

Multilayered Governmental Authority

TEPA has been hindered in implementing several of its control and enforcement strategies. The current four layers of government makes the system top heavy with management and understaffed in technical support, services inspectors and enforcement personnel. There are

excessive delays in conducting impact assessments and issuing permits. There is duplication of functions among the various bureaus. To overcome some of these limitations, the TEPA had to hire approximately 300 contract employees to conduct critical functions. At times, businesses receive contradictory information from central and local government officials. To the extent that TEPA is constrained in carrying out its fundamental function, it will not command respect as an agency for change.

Classic Agency Organization

TEPA is structured administratively, along traditional programmatic lines, i.e., water pollution and air pollution. Adherence to such structure restricts the Agency's ability to incorporate newer innovative programs. Pollution prevention strategies, for example, involve multidisciplinary teams to analyze root causes for wastes (materials and energy). Solutions often require economic, legal, and policy input as well as technical input. Permit programs run by different bureaus burden the regulated community. Cross-training inspection teams give them the capacity to consolidate the permit process.

Staffing Needs

There is a paucity of technically trained staff to conduct compliance inspections and stack testing. The TEPA relies, in part, on contracted services but it does not have adequate oversight capacity to insure high standards of performance. City inspectors handle some of the air pollution inspection responsibility. For the most part, these municipal inspectors do not have adequate training. The diversity of small manufacturers interspersed with residences in Taiwanese cities creates a compliance challenge quite different from the Western experience. Analogies based on the U.S. or European regulatory models may prove ineffective in the Asian political and infrastructure setting.

The Modality of Environmental Management

As a corollary to the issue described above, the current regulatory procedures and administrative structure cannot respond with alacrity to the underlying factors in Taiwanese society causing increases in air, water and soil contamination. The model adopted for pollution control addresses the points of discharge. Short-term indicators show progress because early gains are relatively easy until growth in consumption, transportation and development begins to outpace controls. Environmental quality requires, in the long run, fundamental changes in societal and economic structures to address the underlying causes of pollution. Far-sighted environmental agencies look beyond the apparent sources to develop strategies and alliances incorporating the true value of environmental degradation. It is not clear that the TEPA has the political or public support or the appropriate staffing to undertake such a transformation.

Limitations of PSI

The TEPA has had responsibility to assess and improve Taiwan's environment since 1987. With current expenditures of NT\$ 9.1 billion a year and 600 employees, the TEPA pursues a political mandate to protect human life against contaminants in the air, water and soil. The TEPA discharges its responsibilities through programmatic bureaus dealing separately with air, waste and water pollution. Yet many Taiwanese citizens breath polluted air contaminants above the allowable limits. While there has been some encouraging improvement in air quality, as indicated by the Pollutant Stress Index (PSI), since the early 1990s, monitoring in recent years suggest that continued industrial and transportation growth make future gains more difficult. While the appeal of a simple singular index to convey air quality status and trends is compelling, it often fails to reveal the magnitude or severity of health and ecological problems. Measuring performance by PSI values may mislead public and inappropriately direct financial and human resources. The PSI is limited to a few pollutants, and although it is indexed to health standards, it does not incorporate relative toxicity or severity of outcomes. Social, ecological and aesthetic aspects of environmental quality are not incorporated in the PSI. Therefore, basing the success of an Environmental Quality Program on PSI values rather than on comparative risk could lead to inappropriate emphasis on particular control strategies or research. Evaluating PSI trends does reveal that particulate matter (PM) and ozone (O₃) are critical pollutants resulting in most of the >100 PSI days, with ozone becoming worse in recent years. As TEPA has recognized, reducing

these pollutants further will require nitrogen dioxide (NO_x) and volatile organic compound (VOC) controls as well as further reduction of primary and secondary particle emission sources. The TEPA still has to determine the important emission sources contributing to the PM and O₃ problems, and garner public and political support for further and more aggressive actions. Conveying the necessity for PM and O₃ control is not persuasive by the PSI alone because evidence acquired in the last ten years indicate no discernable thresholds for PM and O₃ health damages.

Environmental Cost Accounting and Economic Incentives:

The current air pollution fee system is based on sulfur oxide emissions and will soon be extended to NO_x emissions. TEPA derives substantial funding from fee revenues. In 1995, fees generated NT\$ 7.3 billions; this had dropped to NT\$ 4.76 billions in 1997 as economic incentives lowered SO_x emissions. Sulfur oxides (SO_x) emissions are relatively easy to determine from sulfur content and amount of fuel consumed. For pollutants like hazardous air pollutants (HAPs), PM and NO_x, determining actual emissions to set a fee will be more difficult. It will require stack testing, process flow evaluations, and a substantial TEPA auditing program for uniformly fair compliance. In addition, for some sources it will be very difficult to assess their annual emissions. There are 98,500 factories, many of which are small in size and interspersed among residences. Emissions from individual factories may be small but the cumulative impact on exposures is great. Further, construction sites emit amounts of particulate matter, both fugitive and from diesel equipment. Air pollution fees for particulate matter and, perhaps, other pollutants will become more complicated as they are applied to a variety of source types.

Beyond technical uncertainties, air pollution fees engender divergent opinions. Some see them as a form of taxation and revenue generating and not necessarily as an economic instrument of social policy. Applying the fee base correctly to encourage the correct emission reductions without having the agency dependent on an income stream is critical and involves sophisticated economic analysis that incorporates health and ecological damage costs, and knowledge of the market response.

To the regulated operator, paying a fee can be interpreted as a permit. Compliance with other regulations could, ironically, become more difficult. They might ask, “Why do I have to do more for these other things when I am already paying a fee to the TEPA?” The fundamental questions that must be addressed concerning the air pollution fee are:

Is it accomplishing rapid, effective and efficient reduction in SO₂ exposures?

and

Is it fair and uniformly applied to large and small polluters alike?

Economic incentives for pollution control have the potential to gain emission reductions faster than conventional command-and-control approaches. This program is more appropriate for Taiwan's situations and, thus, deserves encouragement and support. Economic analysis of the benefits versus costs of the Air Pollution Fee (APF) program should be conducted. Refinement of the fee structure will require monetization of health and ecological damage resulting from air pollution.

Reviewing the APF System

The system for allocating air pollution fees for “control strategies” should undergo periodic review. A majority of the collected funds are used to conduct “paper studies” by local governments, which are not strongly linked to TEPA's specific regulatory strategies. The scientific review and contract management process for projects funded by the air pollution fees is overburdened. As a result, projects are funded that return little in the way of scientific, engineering or economic evaluation of innovative control strategies. An external audit of the program may further erode public confidence in the TEPA and spur business leaders to call for reform (relief from taxation). An internal review and perhaps restructuring might bolster confidence in an agency having the integrity to monitor its own activities. In addition, TEPA should develop guidelines to help local governments to allocate the APF in a more effective and efficient way. Preferably, more funds should be used to invest in instrumental and methodological developments for air pollution measurements, analysis and controls. Funds for

training and educating environmental agency personnel at all governmental levels is also urgently needed in order to upgrade governmental official's managerial skills and technical capability in handling APF.

4. Rethinking Taiwan's Environmental Strategies: Why Now?

In the previous section, we highlighted eight areas that might be considered deficiencies with the current environmental protection system. Here we argue that the timing is right for developing new strategies that, in their essence, will transform the TEPA and increase the public's appreciation and understanding of the value of a sustaining environment.

Institutional Expansion

First, there is a turning point for the legitimacy of TEPA and its Air Pollution Fee (APF) policy. The relatively rich financial source from that APF has created opportunities for TEPA to achieve unprecedented organization goals. The APF policy was introduced to abate urban air pollution in Taiwan. Since then, there has been about NT \$6 billions per annum collected by TEPA. This new source of money via "fee" is large in comparison to TEPA's total regular annual budget, which is about NT \$7.3 billions in 1995. Financially speaking, the size of TEPA has doubled since the APF policy started in 1995. Technically speaking, the APF is surely influencing the existing TEPA's environmental control policies and its relationship with constituencies because APF redefines the consumer's role as environmental shareholders through its direct fee collection system. Such a transformation, accordingly, creates higher societal expectations from TEPA. To some extent, APF is expected not only to achieve TEPA's mission of safeguarding air quality but also will be linked to wider societal goals in Taiwan. Not surprisingly, the APF policy has been seriously scrutinized by academic, political and judicial elite, non-governmental organizations (NGOs), and the media from the beginning because this new policy has direct impacts on consumers and voters. The unusual scrutiny of APF can be best demonstrated by two incidence related to the TEPA in the past two years. The first one is that the ruling party replaced the former TEPA administrator in 1996, partly because of dissatisfaction with the earlier implementation of APF. The other one is that, in 1997, the Grand

Jury of Taiwan reached a resolution of Constitutional Reviews on APF policy, which instructed TEPA to redirect APF 's fee collection and spending policies in order to improve the "equity" and "effectiveness" issues. This was an unusual amount of political attention for TEPA with its normally obscure bureaucratic status in Taiwan's central government.

Divided Governance

Second, there are clear signs from recent elections that Taiwan politics are becoming more pluralistic. Surprisingly, in the December 1997 election, the largest opposition party (Democratic Progressive Party, DPP) gained more votes than the ruling party (Nationalist Party) for the first time in history and controlled counties with over 75% of Taiwan's population. The new political reality will definitely have impacts on the administration of the TEPA, which is an executive branch of the central government, and currently controlled by the ruling party with only a slim majority in the Taiwan Legislative Yuan. As a result, there is the possibility to open up social debate on a broad range of issues. The public's demand for better environment quality has been consistently high over the years. Polls have shown repeatedly that environmental quality has always been the second or third most concerned social and economic issues among Taiwanese adults. In democratic societies, support for environmental programs must ultimately be based on public demand. TEPA should be cognizant that public perception will be more important to their future. Articulation of environmental aspirations will help form the public policy debate.

Decentralized Policymaking

Third, Taiwan is undergoing a restructuring of governmental authority. By constitutional amendment in May 1997, the four-layered system was voted to be replaced by a more efficient, less bureaucratic, two-tiered system. Ideally, the central authorities will work more closely with county administrators and elected officials. In the meantime, the original APF fee collection and spending scheme, which is based on SO_x emissions and administrated by the central government, is gradually being diversified and decentralized. A fee based on dust emissions from construction was already implemented in July 1997, and there will be a fee based on NO_x and SO_x emissions from all sources beginning in July 1998. Local governments are legally mandated

to collect and administrate these two categories of air pollution fee. These changes will make county officers more responsive to the local electorate. TEPA may find it necessary to “customize” some programs to regional situations. This will decentralize governmental powers, i.e. 23 counties and 2 cities will have more say in policymaking than before.

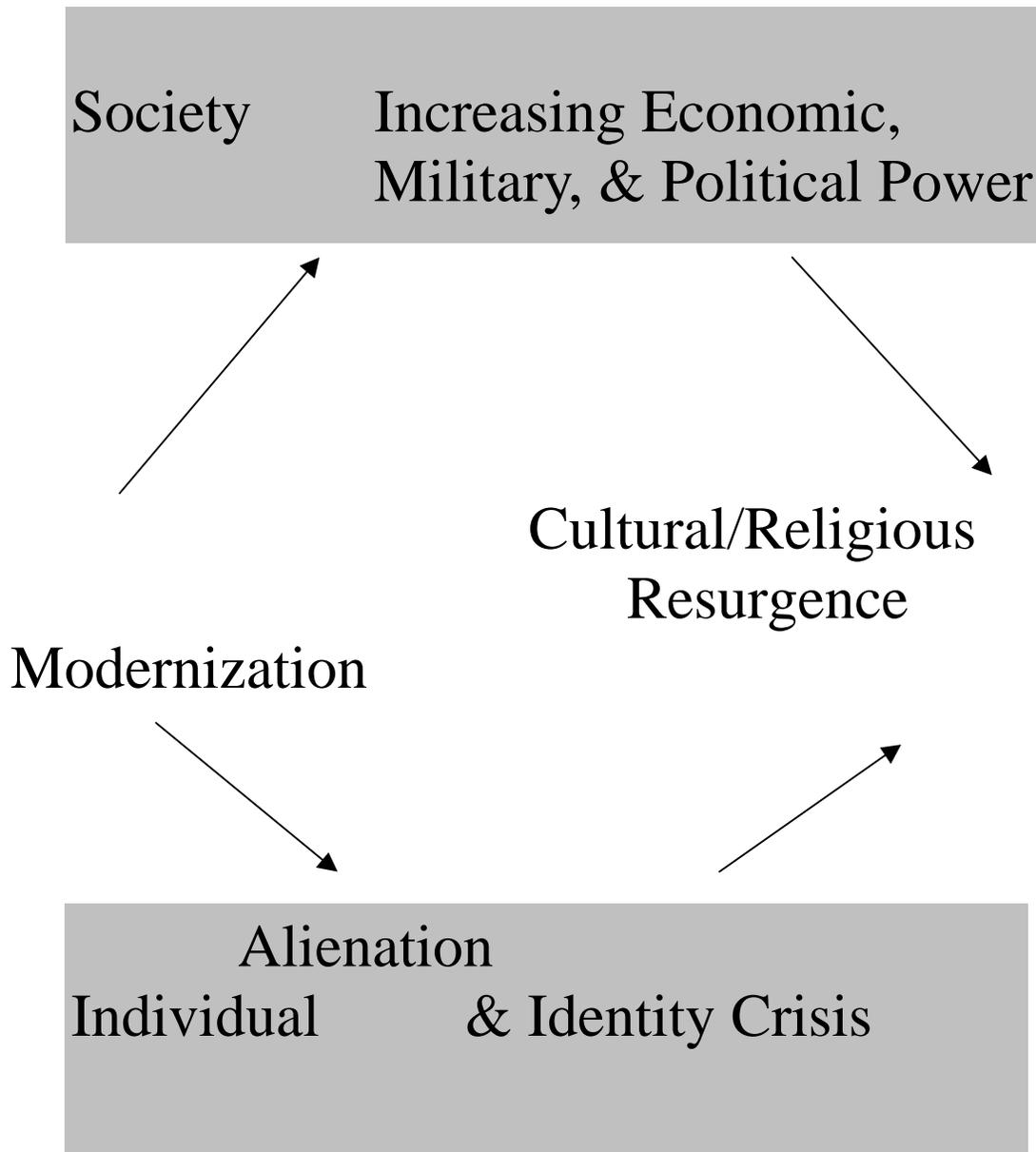
Taiwan’s Chinese Identity and Ecological Philosophy

Finally, Taiwan continues to struggle with its identity. It is a country in conflict between Chinese and Western civilizations. When the world was bipolar, countries were either non-aligned or clearly aligned with pro-western or communistic economies. Taiwan was certainly in the Western camp. Now nations of the world are realigning. According to some political historians, order will be found among civilizations (Huntington 1996). A rationale for defining six globally distinct civilizations is based on religious, legal, institutional and economic structures as well as family structural units. The six primary civilizations relevant to world order are Orthodox, Islamic, Western, Indian (Hindu), Chinese and Japanese. Taiwan, like other “torn” countries, experiences a conflict between its basic underlying cultural heritage and Western modernism. Taiwanese should be observant of raising the assertiveness of PRC, and of a rediscovery of spiritualism in Taiwan itself.

Reaffirmation of religious identifies (Confucianism, Hindi, Muslim, Christianity, Orthodoxy, and Buddhism) is, in part, a response and rejection of Western modernism, which tends to leave individuals without a deep sense of underlying values in a materialistic consuming society. Figure 1 (after Huntington 1996) illustrates political and social stresses that societies will undergo as they are transformed in the early 21st Century. A component of these trends will be growing unrest among youthful populations eager to identify with institutions, concepts, political and religious movements that are perceived to provide substance and direction. It is not at all clear how the turmoil of the first quarter of the 21st Century will come about in Taiwan. Whether regional identity or reuniting with China occurs, Taiwan, like many other populations in the world, will go through an intense period of individual and collective reflection. Individuals and organizations respond to and help shape cultural and social change. The TEPA can be an effective instrument of change as it rethinks its mission, responsibilities, and effectiveness in an

era where people are expecting, and will demand, more “humanism” from all our civic and commercial institutions.

Figure 1 Modernism and Cultural Resurgence



Under such a newly developing world order, what will be Taiwan's identity in efforts to solve regional and global environmental issues? It is no longer in doubt that China with its massive population and rapid economic growth is contributing more and more to the deterioration of the regional and global environments. As a consequence, it has to play a more significant role in finding technical and political solutions to these environmental issues. For years, the way of governing (democratic vs. authoritarian) and the way of living (capitalist vs. communist) have been two obvious contrasts between Taiwan and China. The competition for better political and economic systems has been national security issues on both sides of the Taiwan Strait. Strategically, environmental issues can be another national security issue for Taiwan because they can create a new competition for quality-of-life across the Taiwan Strait. It is particularly pertinent to an environmental agency that it recognizes this period as an opportunity of moving environmental protection from a margin issue to a more central theme in government policymaking.

China (PRC) is reestablishing itself as the dominant country within the Asian hemisphere—a position it enjoyed for than a millenium before Western influence in the 19th Century. Other countries in the region will feel increasing pressures to align with Beijing policy. But China will exert pressure through the cultural identity of Chinese ethnicity and Chinese-dominated commerce in many Asian countries. Taiwan might consider exploiting the same resurgence of cultural identity as it approaches 50 years as a “nation”, but in a different way. By defining development, prosperity, environmental protection and workers’ rights as fundamental tenants of a mature and sustaining culture, Taiwan could begin to invigorate the historical hallmarks of Chinese civilization.

The natural world is not separate from mankind but is part of the continuity of “heaven”. Perhaps because nature is not viewed apart from mankind, it is particularly more difficult for Chinese culture to reconcile concepts of stewardship, management and responsibility for the environment as an obligation of mankind. Critical to integrating concepts of responsibility for the environment into traditional Chinese philosophical thought is making the connection to the life philosophy of “unity of man and heaven”.

Perhaps because an individual human life cannot be separated from the macro-level life of the universe environmental degradation is an accepted “natural” consequence. Fundamental to Chinese culture is placing loyalty to one’s family above self-interest. It is only through filial respect for one’s parents that one most appropriately expresses respect and love for the source of life. Historical continuity is fulfilled through filial love and care of one’s parents, and loving kindness of one’s children. The unbroken stream of life, from past to present and into the future, is the creative continuity of the universe.

An ecological philosophy must link love of nature to love of family. It should espouse that a natural environment, created to continuously nurture all its members, forms the unbroken stream of life. Caring for the vitality of the natural world is ensuring for the future of one’s children. Chinese societies under communism and western capitalism influence never developed an ecological philosophy incorporating the basic beliefs of “unity of heaven and man” into the preservation of nature. The TEPA can encourage a dialog at all levels of social, political and religious life in Taiwan to define the relationships of individuals, family, corporations and government to the environment (cosmos) within the context of Chinese universal ethic.

There are encouraging signs that at the end of the 20th Century, Taiwan leaders are providing the opportunity for societal reflection. Recently, Academia Sinica President, Yuan T. Lee, in a speech in Taoyuan County, said “there needs to be greater love of the Earth” (Lee 1998). He has called upon the government to do more to reduce pollution and for society to recognize the critical path of environmental destruction. “Learning not to damage the Earth” has both spiritual and social appeal. By defining environmental protection as a moral imperative, socially responsible behavior will extend to corporate management. Defining “loving the Earth” as part of an emerging Chinese ecological philosophy will appeal to the human need for relevance and meaning in life. Structuring environmental improvement strategies to embrace these concepts will further assure public and political support. See Figure 2 for more remarks by Yuan T. Lee.

Figure 2 Quotes by Yuan T. Lee, President of Academia Sinica

In an Appeal for Greater Love of the Earth

By Yuan T. Lee, President of Academia Sinica

“Considering development the only goal worth pursuing, Taiwan has been focusing its efforts on industrial growth over the last few decades. This has resulted in an obvious and serious decline in the environment.”

“It [environmental degradation] is going on speeds higher than the majority of the people realize.”

“Most people ignore or underestimate the perils.”

“Learning not to damage the earth is a caution that both the government and the people should heed.”

“—the government must lead in the campaign—making stricter laws to limit pollution emissions and harmful development.”

5. The Strategic Planning Process: How?

We first relied on document reviews to help TEPA identify its strategic position on meeting current and future environmental challenges both domestically and internationally. Recent policy documents and research reports on air pollution controls and air pollution fee published by TEPA and National Science Council (NSC) were thoroughly reviewed. We found out that the command-and-control method is still the main policy tool for air pollution control in Taiwan even after air pollution fee is collected. There is some traditional long-term type of planning activities on air pollution control within TEPA. However, there are no long-term plans for research on air pollution, either by the TEPA or NSC. Most of the TEPA-funded research is problem-driven and involves single-year projects. Funding sources for air pollution research from NSC were relatively scarce before air pollution was transferred from TEPA to NSC. Scientific research has not yet been incorporated into TEPA's policymaking on air pollution controls.

The US EPA's three recent publications on strategic planning have served as institutional references to help TEPA identify common management issues faced by environmental agencies in a democratic society. They are: (1) *EPA Strategic Plan* (US EPA1997a); (2) *1997 Update to Office of Research and Development's Strategic Plan* (US EPA 1997b); and (3) *Beyond The Horizon: Using Foresight To Protect The Environmental Future* (US EPA1995). These documents show that the US EPA has started shifting from a traditional long-term planning approach to a strategic planning approach that contains some of the attributes presented in the previous sections of this report. The participants of strategic planning usually include experts outside the agency, such as academics, industries and citizen groups. One major message from these strategic plans is "...looking beyond the horizon is essential to the nation's future success in protecting the environment." Two recent publications by National Research Council (NRC) in the U.S. are also included in the document reviews. They are: (1) *Linking Science and Technology to Society's Environmental Goals* (NRC1996), and (2) *Building a Foundation For Sound Environmental Decisions* (NRC 1997). These two reports show that either a committee operation or an innovative forum approach can help to achieve timely and sensible strategic planning. Cross-media pollution problems and balance between ecology and human health are stressed in the reports. The energy-environment-population issue is central to the analysis in the

reports. Sound scientific research is deemed to be necessary for good environmental policymaking. The application of social science and risk assessment is helpful to make better societal choices related to environmental problems.

In comparison to other public policies, environmental policy has been a relatively recent development and a marginal public policy activity in most countries. Recent developments in global environmental problems and international trade issues have put the environmental policies in some countries ahead of the rest of world. Governments and citizens have confronted similar agenda for environmental policy in all countries regardless economic development stages. Therefore, we use a "reference country" approach to set a framework for Taiwan's environmental policy. We intentionally use the Netherlands as an example to anchor the ultimate goal of the environmental policy in Taiwan. We will use the development of new modality in the Netherlands' environmental policy to argue the right path for Taiwan's environmental controls. We will also use the Netherlands' capability of integrating disparate policy areas into a coherent environmental policy to recommend several conceptual and institutional changes needed for a better environmental policy in Taiwan.

In the third step of our planning process, we applied detailed quantitative data analysis in order to recommend more specific policy tools for air pollution controls in Taiwan. We relied on correctly diagnosing the situations and causes of air pollution in Taiwan to serve as a scientific foundation for proposing a substantively valuable control strategy for TEPA. We applied time-series and cluster methods to analyze air quality monitoring data from 1993 through 1997 in order to identify temporal and spatial distributions of air pollution problems in Taiwan. Relevant emission data, provided by TEPA, are correlated with observed ambient air concentrations. It is also apparent that we will not come up with a substantively valuable policy without considering the large social, economic, and technological forces that are driving changes in Taiwan's air quality. By reviewing published documents on air pollution studies, we were able to illustrate the relationship between driving forces and outcomes of air pollution problems in Taiwan. Based on these findings, we drafted a control strategy and a list of related research and development (R&D) topics to serve as a blue print for further consultation in interviews and workshops.

After strategic plans were drafted, we then conducted on-site visits to related regulatory and research institutions, interviews with key policymakers and workshops with academic and governmental officials in Taiwan. These activities serve as the first step towards legitimizing our strategic plan among the elite in Taiwan. We will continue to use such opportunities to gather in-depth information from concerned parties to improve operational and administrative feasibility of our strategic plan. Due time limitations, we did not perform a comprehensive feasibility study on our plan.

In late March and early April, we held a series of bottom-up interviews with TEPA's officials. We first had a group discussion with all branch directors and senior officials in TEPA's air quality branch, and had individual interviews with TEPA's administrator and the director-general of TEPA's air quality branch. Through these interviews, we are able to include the administrative concerns and constraints into our strategic plan. We learned that TEPA's officials are leaning toward a new spirit of government partnership programs with private sectors. We also had a discussion with the president of Academia Sinica, Dr. Yuan T. Lee, who is the key person in making science and technology policy in Taiwan. We were delighted to learn that there is a philosophical awakening toward the environment among key scientists in Taiwan. We also found out that the energy-environment paradigm in our strategic plan is in line with current thoughts of academic circles in Taiwan. Early in June 1998, we will have another three interviews with governmental officials in Taiwan, which are one with vice-premier, one with TEPA administrator, and one with personnel of TEPA's environmental monitoring branch. We have discussed the energy-environment issues and institutional expansion proposals with the vice-premier of the Executive Yuan and TEPA's administrator. We learned that the Executive Yuan is planning to include the energy into the jurisdiction of the planned Ministry of Environment and Resources in Taiwan. We also learned that TEP administrator agreed with most of the findings and recommendations of our strategic plan and promised to put them into action plans after feasibility study in the future. The meeting with the environmental monitoring branch concluded that the branch's function should expand to include environmental statistics, exposure assessment, particle component and ozone precursor monitoring.

We also had an interview with the leaders of the largest citizen group in Taiwan, the Tzu-Chi group. We have learned that the Tzu-Chi group is willing to expand its current recycling

project to other environmental programs, such as setting a green and sustainable building demonstration program on its planned building sites. We also learned that Tzu-Chi is planning to set up a new environment-related department in its planned new university from Dr. Ming-Liang Lee, dean of Tzu-Chi Medical College.

We have held a total of four workshops to extend our interaction with wider academic and governmental audience. The first workshop, held in April 1998 in Taiwan, was a joint TEPA-US EPA workshop on "Urban Air Quality and Emerging Issues on Global Air Environment". This workshop included 26 participants from academia and government in Taiwan and the US. Our strategic plan has been used as a framework for discussing and formulating a policy agenda for TEPA's air pollution control. We held another three mini-workshops to engage more participation from governmental officials and academic people in Taiwan in June 1998. The topics of these three mini-workshops are particle toxicity, environmental statistics, and CO₂. These topics were selected because they are some keystones for our strategic plan, which deserve further discussions in this report. There are approximately 10-15 participants in each mini-workshop. Detailed information from these interviews and the agenda from the workshops are list in the Appendix B.

The distribution of our report is the last step of our strategic planning process. We will have a formal oral presentation of this report for the TEPA and for Harvard University. The report will be published in Chinese and English, and both printed and electronic versions will be available. The documents will also be made available on the TEPA, National Taiwan University and Harvard web sites. We expect to use this method to enhance public participation in the strategic planning process. We will recommend a follow-up study on integrating public comments and policy's feasibility into the final version of strategic plan in order to complete the exercise of a strategic planning cycle.

6. The Ambient Air Quality Situation in Taiwan: Concentrations, Exposures and Emissions

Concentration

In Taiwan, an air monitoring network with 66 monitoring stations, the Taiwan Air Quality Monitoring Network (TAQMN) was established in 1993. The TAQMN has recently been expanded to include 71 monitoring stations. Hourly air pollution levels can be obtained from the continuous measurements of SO₂, NO₂, CO, PM₁₀, and O₃ at these 66 stations. The national air quality situation can be measured by comparing the air pollution levels with appropriate National Ambient Air Quality Standards (NAAQS) for each criteria air pollutant. The air quality analyses presented in this report consist of four-year monitoring data from September 1993 to August 1998. Comparisons of air quality regionally can be achieved by simultaneous comparisons of air pollution levels in the 8 air basins designated by TEPA.

TEPA has been using the Pollutant Stress Index (PSI) to evaluate the overall air quality in Taiwan. The air quality is rated as unhealthy when PSI>100. The percentages of unhealthy days are about 7% in 1994, 6.1% in 1995, 6.6% in 1996, and 5.3% in 1997. The main pollutants responsible for unhealthy days are PM₁₀ and O₃. Both annual and daily NAAQS for PM₁₀ and O₃ were consistently violated between 1993-1997.

The ambient air quality was found to be significantly different among air basins and seasons in Taiwan. In general, the air quality in the island's eastern (Zone VII) and northeastern (Zone VIII) regions was much better than other regions. The air quality in summer was much better than the other three seasons in most air basins except the northern region (Zone I). For areas from central to southern parts of western Taiwan, annual average PM₁₀ concentrations ranged from 67-87 $\mu\text{g} / \text{m}^3$ in 1997. The days with 24-hr PM₁₀ concentrations above 125 $\mu\text{g} / \text{m}^3$ ranged from 27 to 134 for most western Taiwan in 1997. The days with 1-hr O₃ concentrations above 120 ppb ranged from 11 to 182 for most western parts of Taiwan. Since there were significant area differences in TEPA's 8 air quality zones, we applied cluster analysis to examine spatial patterns of air quality in Taiwan. Our results indicate that the current classification of 8 air

quality zones in Taiwan is not consistent with the monitoring data. In stead, there are only 4 zones for PM₁₀ and 5 zones for O₃ as illustrated in Figures 3 and 4. Therefore, we recommend that TEPA should base its classification on 4 to 5 zones rather than 8 zones when forming its control strategies in the future.

The clusters of air basins for PM₁₀ and O₃ indicate that there is a possible upwind-downwind effect on the transportation of these two pollutants in central and southern Taiwan. The equity issue associated with upwind-downwind transport of air pollution needs to be further examined in order to improve TEPA's air quality management policy. The monitoring data from traffic sites show that air pollution levels are exceptionally high on the roadways in the Taipei metropolitan areas.

The trends for ambient air concentrations over the past four years were then examined by time-series analyses. We found a significant island-wide decrease in SO₂ and CO concentrations. We found that the majority of monitoring stations also had a significant decrease in PM₁₀ and NO₂ concentrations. Average PM₁₀ concentrations decreased about 1 to 2 mg / m^3 since 1993. In contrast, most monitoring stations showed consistent increases in O₃ concentrations over the years. Mean 1-hr peak O₃ concentrations increased about 1 to 2 ppb since 1993. In spite of these changes in individual air pollutant concentrations over the years, most parts of Taiwan are still in the non-attainment air quality regions when compared to the NAAQS.

Figure 3 Four PM₁₀ Air Basins in Taiwan

Figure 4 Five O₃ Air Basins in Taiwan

Exposure

By combining air pollution data and population statistics, we can assess population exposure to air pollution in Taiwan. We estimate that about 1.45 million people were living in PM₁₀-polluted areas (daily PM₁₀ > 125 $\mu\text{g} / \text{m}^3$) and 1.33 million people were living in O₃-polluted areas (daily maximum 1-hr O₃ > 120 ppb) in Taiwan every day in 1997. On yearly basis, there are about 10.44 million people living in areas where yearly-averaged PM₁₀ concentrations were above 65 $\mu\text{g} / \text{m}^3$. Among these exposed people, about 80% reside in the central to southern part of Taiwan. These figures indicate that PM₁₀ and O₃ pollution can potentially be a serious public health problem in Taiwan. The health problem associated with air pollution can be especially serious for the residents in southern part of Taiwan.

In addition to criteria air pollutants, non-criteria air pollutants may also pose serious exposure for residents in metropolitan areas. Studies have found that mean benzene concentrations in Taipei are about 5.8-7.7 ppb. Commuters are exposed to about 58 to 130 ppb benzene during commuting hours. On average, such exposure levels in Taipei are about 3-8 times higher than in Los Angeles, CA, USA (Chan et al. 1993).

Emission

As of 1996, there were approximately 21.47 million people (596.43 persons/km²), 96,850 factories (2.69 factories/km²), 13.2 million vehicles (367 vehicles/km²) and over 100,000 projects of on-going construction in Taiwan. If we put these figures in an international perspective, we can easily see that the environmental loading in Taiwan is very high. The population density is about 22 times that of the US, 1.7 times that of Japan, and 1.4 times that of the Netherlands. The vehicle density is about 18.5 times that of the US, 1.7 times that of Japan, and 2.0 times that of the Netherlands. The factory density is about 1,000 times that of the US, 3.8 times that of Japan, and 10 times that of the Netherlands. In addition, the energy consumption is also very high in Taiwan. It is estimated that about 72.5 million kl oil-equivalent units of total energy was consumed in 1996. To supply the direct energy needs about 13.5% coal, 42.5% oil, and 4.0% natural/liquefied propane gas are used in industrial production,

transportation and household consumption. The remaining energy demand is met by electricity. Electric power comes from about 2.9% hydropower, 24.5% coal/oil/natural-gas power, and 11.6% nuclear power. These drivers (energy, population, vehicles, and factories) are expected to generate a significant amount of stress on air environment in Taiwan.

The emission inventory shows that there are about 534,567 metric tons of PM₁₀, 407,201 metric tons of SO_x, 426,399 metric tons of NO_x, 852,212 metric tons of NMHC and 1,720,849 metric tons of CO emissions in 1997. For PM₁₀ and SO_x emissions, over 90% are from the stationary sources and less than 10% from mobile sources. The stationary and mobile sources have equal contributions to NO_x emissions. For NMHC emissions, about 2/3 are from stationary sources and 1/3 from mobile sources. For CO emissions, 83% are from mobile sources and 17% from stationary sources. The emissions also show significant geographical variation. Most emissions are concentrated in the metropolitan and industrial areas of western Taiwan.

The stationary and mobile emission sources can be further classified into detailed emission categories. The national PM₁₀ emissions by key source category are ranked in the following order: road dust (46%), construction (17%), industrial process and utilities (8%), open burning (5%), diesel vehicles (4%), motorcycles (3%) and gasoline cars (2%), and others (15%). The national NO_x emissions by key source category are ranked in the following order: diesel vehicles (29%), utilities (21%), gasoline cars (17%), industrial combustion (13%), industrial process (11%), motorcycles (2%) and others (7%). The national NMHC emissions by key source category are ranked in the following order: motorcycles (21%), commercial solvent application (17%), architectural application (14%), gasoline cars (11%), industrial process (10%), industrial surface coating (8%), petroleum-related industries (5%), diesel vehicles (2%), and others (12%).

7. Strategic Plans for Environmental Control

New Policy Initiatives for TEPA

TEPA has a legislated mandate from the federal government to enhance Taiwan's environmental quality and to protect Taiwan's citizens from harm caused by environmental contaminants. Within this broad mandate, TEPA develops policies, programs and regulations to curb pollution and improve the environment. To date, those policies have followed the more classic structure seen in Western countries, to be more specific, like that of the US EPA. Some customization to the local context has been made. We maintain, however, that the Agency can and needs to be more effective, particularly in light of national, regional and global concerns. In this section we argue for four policy initiatives that create the operating principles for the TEPA. Its internal and external operations should be consistent with these (or other) policy goals.

TEPA should consider these four strategic areas in the context of modality shifts influencing environmental management. Figure 5 characterizes four phases of environmental management. Most federal programs in Western societies have statutes, regulations and programs that reflect the early phase when governments reluctantly interfered with the free market forces of commerce. It was quite obvious that environmental improvement came at the expense of sources. Air emission limitations for mobile and stationary sources were established, expensive investments in waste water treatment were required, and remediation of contaminated land to very clean conditions demanded forceful governmental action.

We argue that a more mature TEPA should be in transition. During this phase economic interests are no longer viewed as being subjugated to ecological concerns. Well-being of society is synonymous with the health of its people and long-term viability of its natural environment. Investments in pollution remediation, emission controls, energy and material reduction are seen as contributing to the economy through job creation, efficiencies and damage reduction.

Figure 5 Environmental Modality for Environmental Management

Early Phase

OPPOSITION

Economy vs. Environment
Government vs. Industry

Mid Phase

SOURCES

Regulation-Reduction of
Existing Sources

Transition Phase

LINKING

Environmental Quality +
Standard of Living =
Economic Value

Late Phase

ALL SECTORS

Ensuring Sustainable
Development

It is important to understand that there is a “next” phase. To achieve environmental quality while anticipating population growth and a desire for an increase in standard of living will require sustainable practices across all sectors of society. New management models and even institutional/financial structures may be required. Taiwan may do well to look to the Netherlands as a new reference country offering a model to change through national energy and environmental policy.

The Dutch experience may appeal to Taiwan. The physical size and population of the two countries are similar, as are their degree of industrialization. Ten years ago, the Dutch started in the transition phase with tremendous popular support and political leadership. The Dutch Parliament passed a National Energy and Environment Plan to stem the dire projections about the quality of life and the degradation of the environment projected some 25 years hence. Prior to this national legislation, public support was galvanized by a widely distributed and publicized report on their environmental future. Industry cooperation was assured because the environmental agency had enforced its regulation with integrity.

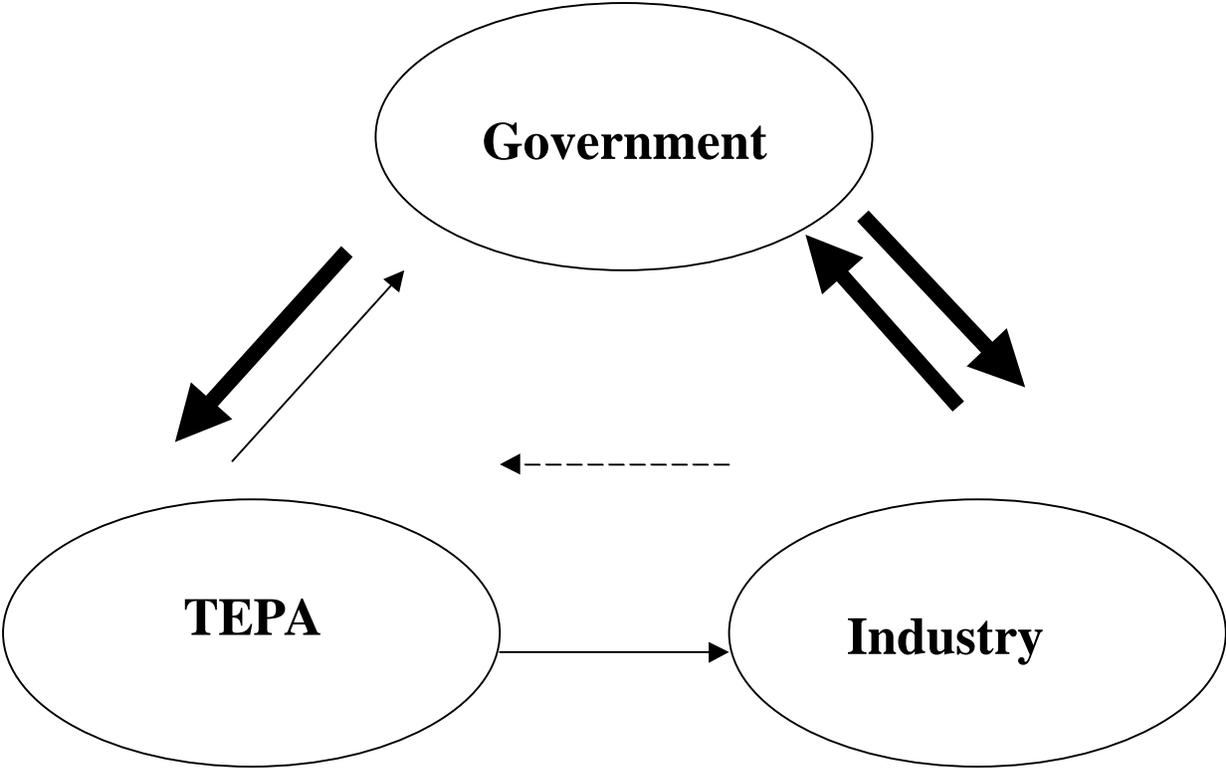
We refer to the Dutch experience in this report because through their policy and strategy documents they offer a radical but necessary departure from the environmental management structures of other countries. The Dutch clearly recognize the need to couple their domestic goals with international diplomacy if they are to be successful with their “late phase” sustainable development programs.

TEPA Must Define New Contextual Relationships Among Its Many Constituents

In a traditional sense, TEPA receives its authority and charge from legislation passed by the Legislative Yuan. From this mandate, TEPA engages in pollution control activities through a variety of instruments to influence emissions from industry. Figure 6 depicts the triangle relationship among the government (central and local), TEP and industry. To the extent that industry has had for some time direct access to both legislative and administrative branches of the branches of government, TEPA’s authority is tempered.

Figure 6 Triad relationship between Government, Industry, and the EPA in Taiwan. The relationship is unbalanced.

TEPA in Contextual Setting

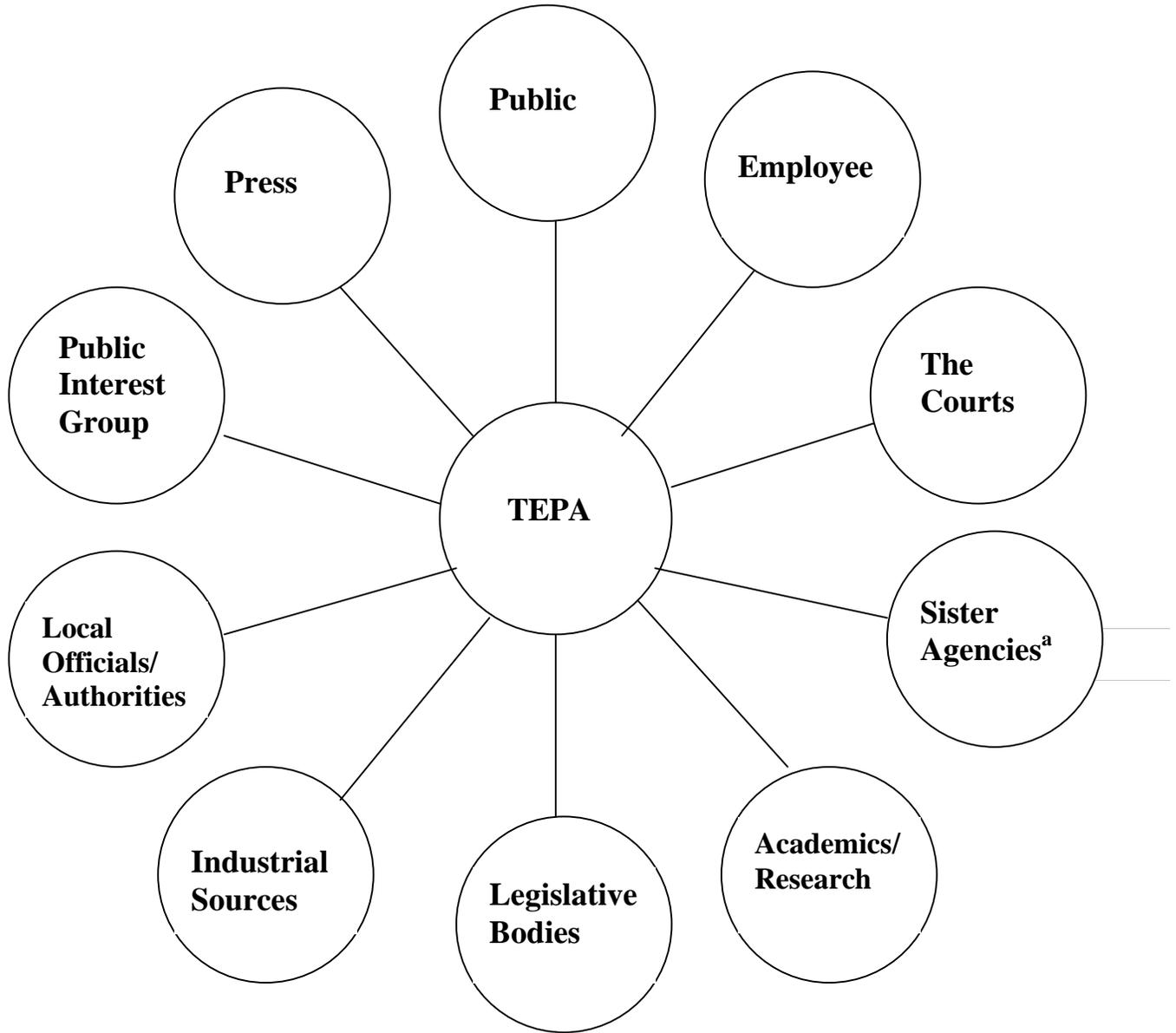


After judicial review, economic pollution control incentives, such as fees, can be interpreted as asserting TEPA authority. It remains to be tested whether TEPA can maintain an authoritative position when the air pollution fee structure is extended. One might think that efforts to restrict TEPA's ability to impose additional air pollution fees would be instigated by industry when faced with more substantial charges for SO₂ and NO₂ emissions. The Agency might be advised to anticipate further politicization of their strategy to use economic incentives.

In the face of this possibility, the Agency must view itself in the broader context of Taiwan society. As depicted in Figure 7, the TEPA has many constituents. Among them are the public, non-governmental organizations (NGOs), local and central governmental legislatures, and other central ministries/agencies. From interviews in March 1998, it is obvious that Administrator Tsai has already implemented programs involving public interest and religious groups. Garnering public and legislative support for environmental actions that challenge local political interests should be primary mission of the Agency. Yet, more can be done to develop a culture of environmental protection within broad and diverse elements of Taiwanese society. Table 1 gives some ideas of how to proceed.

| Table 1 New Initiatives for TEPA: Contextual Relationship | |
|---|--|
| Trust of Initiative | Comments |
| Define TEPA in relationship to constituents it serves Build trust and confidence with these groups Assess how TEPA is perceived | Process may take a year or two with many interactive task groups Form new partnerships with NGO's, government agencies and businesses Be prepared for tough criticism at first |

Figure 7 TEPA in Contextual Setting



^aTransportation, Construction, Housing, Education and Economic Affairs

The Dutch recognize that “the public forms the societal support base for environmental policy. It is they who largely determine how ambitious policy can be and which measures are acceptable. The public are also consumers; the ‘consumer’ target group contributes to several of the environmental themes.”(NEPP3 1998) The Dutch environmental policy plan targets education to modify environmental behavior, develop programs for societal organizations and encourage life-cycle assessment (LCA) to allow the public to discern among products.

The Agency might contemplate strategies that cultivate cooperation with responsible industrial groups. Figure 8 illustrates the evolution of environmental management. Starting in the lower left-hand corner, government control over free enterprise increases with issuance of permits and standards. Negotiations follow a transition built upon fostering authority, trust and flexibility in dealing with the regulated community. In a negotiation modality, the relationship between the Agency and industry becomes bi-directional and mutually beneficial.

The Dutch National Environmental Policy Plan (NEPP3 1998) discusses covenants established by industrial sectors and the government (environmental agency). The Dutch report that “companies are increasingly taking the initiative to establish their own active environmental policy, and are incorporation the environment in their corporate strategy. This has led to emission cuts, instituted in part by the target group policy pursued (the covenant approach), licensing and regulation.”

The ISO 14000 series for industries provide an opportunity for the Agency. To earn ISO 14000 certification, a company must evaluate its energy consumption and environmental emissions. The director of air quality branch of TEPA, Mr. Hsiung-wen Chen and his colleague Ms. Shu-hwei Fang (1997) argue that the ISO 14000 voluntary environmental and energy management programs for industries are incentives that result from real or perceived market pressures. Today, we believe less than a dozen Taiwanese companies are participating in ISO 14000 requirements. The advantage of the ISO program is the requirement to demonstrate improvements (reductions). The Agency might promote ISO participation even by offering rebates on pollution fees for companies that sustain reductions and openly share their emission

data. We argue, however, that the Dutch covenant approach is preferred. Companies losing their ISO 14000 certification no longer have incentives to improve. A sector-deprived covenant program could include self-policing, outside auditing, random inspections and reporting open to the public among other components to assure compliance.

From discussions with TEPA staff, the Administrator and others during our March/April visit, we recognized that new developments in Taiwan's air pollution program are structured to provide inducements. Strategies and management instruments are similar to those in the lower box on the right-hand side of Figure 8. There may be cultural and political factors making negotiated strategies less workable in Taiwan. An important component for pursuing negotiated strategies would certainly be creating "self-interest" within the industrial sectors. Information placed in the public domain about discharges, violations and improvements can motivate industry to establish and publicize its goals and programs.

Responsibilities of TEPA's sister agencies, in many circumstances, have environmental impacts. TEPA must start to exploit relationships with other branches of government by establishing environmental partnership programs. These agencies each have a target sector and their own constituency.

The Ministry of Economic Affairs (MOEA) oversees the economic engine of Taiwan. Among its function is the promotion of industrial sectors deemed vital to Taiwan's security and economic interest. Specific industrial activities are encouraged through loans and tax incentives. Environmental considerations currently do not influence the decisions of the MOEA. Government industrial subsidiary policy certainly has implications for natural resources, energy and generation of hazardous waste that must be treated. Establishing new industrial parks will cause some companies to relocate and others to expand their operations. Through government actions, "brown fields" will be left that require clean up for most non-industrial use.

Figure 8 Evolution of Environmental Management

Negotiated Transition

| | | |
|-------------------------------|---|--|
| Government Control | Regulation Permits Emission limits | Negotiated Framework for regulation Covenants |
| | Unconstrained Competitive market Tort litigation | Induced Air permit trades Energy tax Subsidies |

After: Paul Hofhuis, Counselor for the Environment, Royal Netherlands Embassy,
 “Silent Revolution” Conference, Washington, D.C., Feb. 1998

We understand that draft legislation attempts to address some of the shortcomings of current government industrial policy and programs. Criteria for energy use and environmental impacts need to be incorporated into government investment policy. To the extent permitted by law, TEPA should collaborate with MOEA to draft criteria that encourage energy conservation, remediation of contaminated land and reduced environmental externalities. Basically, the security and quality of life issues embedded in energy and environmental concerns have to be articulated during discussion addressing industrial policy.

In Taiwan, where many small-sized industries are in residential sections, local air pollution and company activities may be closely linked. Taiwan's Council of Labor, responsible for worker health, will obviously understand a great deal about manufacturing processes, workplace exposures and hence potential impacts on local environments. Collaborations and even cross-training between TEPA and the Taiwan Institute of Occupational Safety and Health (TIOSH) staff might be mutually beneficial. TIOSH concerns itself with chemical toxicity, control techniques and even pollution prevention and certainly has common ground with TEPA's mission. Further, workplace controls may have created adverse exposures in the neighborhood. Vice versa, control of discharge effluents might lead to unexpected workplace hazards.

There are many direct links between farming and the environment. Farmers and their organization would obviously be concerned about eutrophication, depletion or contamination of surface water and groundwater, and diminished crop yields because of ozone and acidification. TEPA should forge alliances with the agricultural community based on their self-interest. Such alliances will be important to formulate policy, to lessen the impact of pig farming (manure, nutrients, ammonia), fertilizers (phosphates and nitrates) and pest management.

Taiwan's Council of Agricultural Affairs through its influence on farming practices and land use can greatly influence the environment. Taiwan's entrance to World Trade Organization (WTO) will open up the food market to imports. This has implications to land use and hence the environment. Taiwan farmers may experience pressure to convert farmland to other uses. It is possible that construction firms have already anticipated these events. TEPA and the Council of Agricultural Affairs should consider the long-term implications of development at the expense of

farmland. Conversion of farmland may mean a loss of water retention capacity during heavy rains. Increased runoff can strip nutrients from remaining farmland and cause ecological upsets in receiving rivers and estuaries. Loss of open space has quality of life implications and further separates people from the “natural” world.

The Ministry of Interior, MOEA’s Council on Energy and TEPA have a common interest now in promoting energy efficiency. Cooling and lighting interior spaces in homes, office buildings and other structures requires considerable amounts of energy. Encouraging conservation through building codes has multiple benefits. Besides the obvious financial returns from reduced energy consumption, green house gases are reduced along with ozone-forming gases and particle pollutants. The returns to society for doing simple things now like improved low-energy emitting windows and efficient lighting has immediate benefits with rather short payback. A more substantial investment in building research with the mandate to investigate technical, social and economic issues promoting demand-size reduction of energy use could be the basis of collaboration among many federal agencies.

Within Taiwan’s Ministry of Education (MOE) there is an Office for Environmental Education. This office and the TEPA should commission a study on the environmental manpower/training needs across all sectors. Once charged, the commission would evaluate the training currently provided by universities and vocational schools and how these schools are meeting the needs of agencies and industries. It is clear from our vantage point that environmental scientists and engineers will need more training in economics, accounting and organizational management in order to complement their technical skills. Environmental controls and energy-efficiency strategies will be evaluated more and more on the basis of economic returns to industry and society. The TEPA appears under staffed. As it pursues economic incentive control strategies, it must increase its ranks with people skilled in economic cost analysis and knowledgeable about cost accounting. It is also evident that the business sector must bear a substantial responsibility for improving environmental conditions. Therefore, adding environmental cost accounting and case studies demonstrating efficiency gains of pollution prevention programs should be developed as core curriculum content in a business school education.

Ultimately, our environmental future depends directly on the knowledge, behavior and support of a large sector of society. TEPA should cooperate with MOE in establishing environmental curricula full of local content at all levels of education. With inexpensive sensors, test kits or even standardized observation, every science class might provide valuable information on environmental conditions across the Taiwan. Universities might be encouraged through TEPA/MOE annual awards to make their campuses ecologically better. Numerous environmentally relevant problems can be found on university campuses, from recycling to transportation. Turning these problems into instructional activities will help prepare Taiwan's next generation of young professionals.

Create Opportunities to Link Environmental Objects with Other Economic and Social Goals

TEPA should define the common ground between commercial interest and environmental health. Unfortunately, too many see environmental regulations as “either/or” choices. Economic competitiveness and environmental remediation are considered diametrically opposite. Porter (1990) offers a view that environmental regulations might actually stimulate economic development. He writes

“Strict government regulations can promote competitive advantage by stimulating and upgrading domestic demand. Stringent standards for product performance, product safety, and environmental impact pressure companies to improve quality, upgrade technology, and provide features that respond to social demands. Easing standards however tempting, is counterproductive.”

The Dutch government in 1989 established a national policy to reduce energy and improve the environment. Springing forth from this national policy were many creative programs initiated by all sectors of the economy. Government agencies established goals, performance

criteria and stimulated innovation by challenging the private sector through a variety of large-scale demonstration projects.

TEPA could set the leadership by joining with other agencies to begin articulating the social, economic and environmental goals for Taiwan. Political leadership is obviously required for seemingly radical policy changes, but agency leadership could begin to set the course. Encouraging electric vehicles could be an excellent example that would include dedicated transit corridors favoring construction contracts that demonstrate alternative transportation opportunities, establishing motor vehicle free commercial zones and the like. Beyond articulating the environmental benefits of such integrated planning, the TEPA should be prepared to quantitatively demonstrate “proof of concept” with high quality cost-benefit, risk and life-cycle analysis methods. The Agency will have to present the environment’s case with health and economic analysis. This will require encouraging academic inquiry to refine the methodologies and new talent for TEPA, as well as other agencies.

The *Conference on Global Climate Change* in Kyoto has created an opportunity to consider the relationship between environmental management and energy use. Even more than national environmental concerns, the distinct possibility that mankind is contaminating the atmosphere causes a sense of apprehension. Kyoto shifted the debate from the domain of the scientist to that of the diplomat and international energy companies. Serious and substantial national and international action to reduce carbon dioxide (CO₂) is now possible.

The Dutch have recently expressed their international environmental policy, post-Kyoto. On climate change, the Dutch state “by comparing our energy performance with that in other countries and adjusting policy accordingly, our contribution to solving the climate problem will be optimized.” The Netherlands will be pressing to see environmental aspects incorporated into the Multilateral Agreement on Investments in the rules of the World Trade Organization.

TEPA should be elevated to the ministry level. Environmental degradation from domestic sources and transported pollutants from sources in southern China are serious issues for Taiwan. Increasing reliance on financial incentives to modify polluting behavior and international trade

pressures to curb energy emissions are other valid arguments for elevating TEPA to ministry level. With cabinet status, TEPA's Administrator is better able to articulate the environmental implications in the formulation of energy, industrial and social policy. Taiwan's federal government would be better structured to incorporate environmental and energy concerns into the myriad of actions it faces, ranging from public works projects to government reform.

Elevation of the TEPA to Ministry for the Environment is a quality of life statement for Taiwan. It is an expression that preserving and enhancing the nation's air, its rivers and land is a responsibility that is as important as economic growth, education and security. The symbolism of cabinet status alone for the TEPA creates value for the environment.

Enforcement Through Persuasion

Strict enforcement of environmental regulations can force competitiveness. In our interview with Yuan T. Lee, the importance of strict enforcement was stressed. Enforcing environmental regulations uniformly and fairly gives the Agency the integrity it needs to promulgate alternatives to command and control strategies. Public perception can also pressure compliance and improvements. There is growing expectation among Europeans that private companies will act ethically. Ethical behavior extends to conditions of the workplace, treatment of employees and care for the environment. Public sentiment can exert strong motivation on corporate actions. Companies will comply with regulations because it makes good business sense. In part, attitude among European and North American consumers reflects the transitions underway in post-modernism Western culture. The growth of "green investment funds", activism among stockholders, boycotting of brands or products portend the shift from fringe concerns to mainstream behavior.

While similar trends may not be apparent in Asia yet, it should be of no less interest. Globalization of information enables consumer groups to monitor the manufacturing processes whether they occur in PRC, Mexico or across town. TEPA should be in a position to harness information technology and change consumer attitudes. Public disclosure of industry performance and emissions compliance is a direct way of rewarding responsible behavior and

changing bad behavior. Providing companies and the public with technical information, such as illustrating industry examples that serve as benchmarks for measuring performance, creates the knowledge and incentives to improve. In fact, social suasion is one of the few options available to TEPA to influence companies establishing operations on the mainland. It is in Taiwan's self-interest to ensure a high level of environmental care for the Taiwan companies manufacturing in southern China. Individually their impact on Taiwan's air quality is small. In the aggregate, however, transported air pollutants and ocean contamination could affect Taiwan's environment.

The European and North American experience with acid deposition and degradation of crops, forests, and lakes has been acknowledged for at least ten years. Pursuing various policy considerations in Taiwan now may be useful for pedagogical reasons as well as political reasons. Important scientific questions about environmental processes in the region could be addressed as the policy tools are examined. With a trans-boundary pollution policy directed at Taiwan's companies operating elsewhere in southeastern Asia, Taiwan articulates environmental values, builds local technically trained capacity, and exerts a positive influence throughout the region. Appendix C1 describes long-range transport of acid aerosol in East Asia. Industrial and energy growth in PRC has important implications to air quality, agriculture, forest and even surface water quality for countries downwind. The Appendix briefly describes work underway in Japan to study these impacts.

Improve Environmental Quality Through Eco-Innovation Technology

Tremendous gains in environmental quality, energy and land use efficiencies, and general quality of urban life could come about with technological breakthroughs. With world oil prices as low as they have been in 20 years, the market is not signaling energy efficiency. We must recognize that the free-market economic structure in its current form of cost accounting will not stimulate eco-innovation. What will instigate change are material shortages, health and ecological risk, consumer preference, regulations, and pressures through international trade. Regulations can create a demand in the marketplace for more efficient use of materials and energy where conventional pricing mechanisms fail. Government can encourage innovation through performance standards, codes and specifications. However, if these are not carefully

structured they can have the opposite effect. TEPA should first understand the dynamic interaction between government actions and competitive innovation.

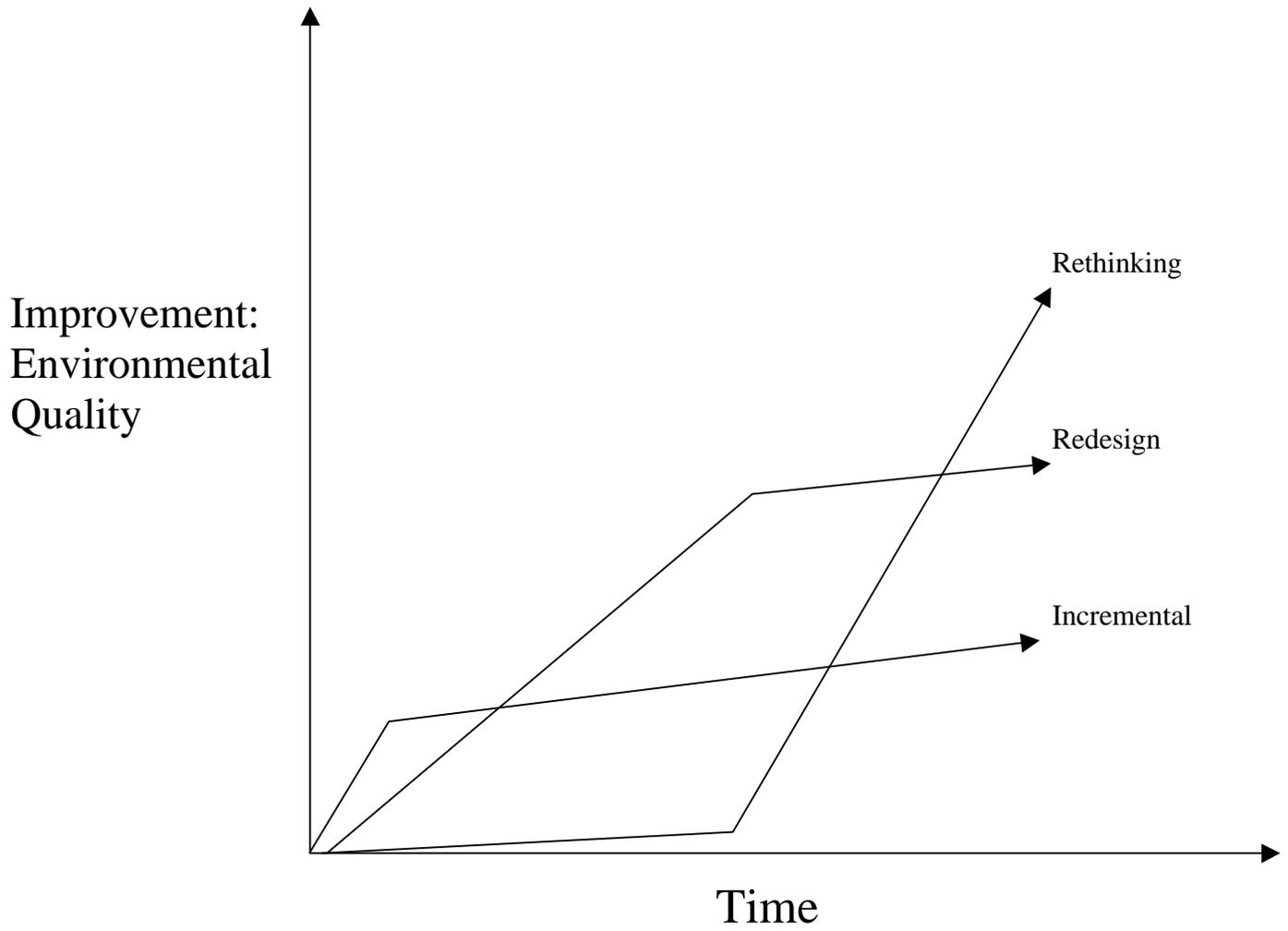
Government-funded programs can create high technology markets for specific needs (e.g., military) but often these are not applied to more conventional areas like housing, building and transportation. The TEPA should examine a variety of policy options within the framework of creating a market for eco-technology. Several countries and some states in the U.S. have pursued industrial “greening” policies. Establishing recycled material for new construction, packaging minimization, full recycling of products, emission limits for the organic compounds in rugs and paints (or in some cases furniture), disclosure in Material Safety Data sheets, and toxic release inventory reporting are among the many additional options that could be pursued. The entire field of mortgage financing, liability insurance, taxation and publicly financed demonstration projects could stimulate technological eco-innovation.

Interestingly, several large corporations have initiated ecologically driven technological innovation without the overt stimulation of government actions. Companies like Sony, BMW, Dupont, and many others have reorganized competitive advantages to ecologically re-design products—less energy, fewer materials and more recycling contribute to the bottom line. Less tangible but no less important is the motivating influence of socially responsible manufacturing on motivating workers and the sales force. Sustainable manufacturing and environmentally friendly products will have increasing influence on consumer preference.

The importance of encouraging a recreation of business policies is illustrated in Figure 9. Regulations that require pollution control equipment can be implemented rather quickly but will eventually reach a plateau where the environment does not really improve. In fact, more commercial economic growth will eventually erode those gains. Ozone air pollution in the US, Canada, Europe and Japan are graphic examples. Despite the fact that automobile carbon monoxide, hydrocarbon, and nitrogen oxide emission controls make current vehicles almost 98% “cleaner” than automobiles produced in the early 1970s, ozone is more widespread than ever with some 60 to 80 million people in the U.S. living in areas exceeding health standards. Sub-division of property in the suburban fringe, separation of homes from work, schools and shops,

and investment in roads have contributed to a 122% increase in vehicle miles traveled over 20 years in the U.S. and together with growth in electric power generation have contributed to our ozone and fine particulate problems.

Figure 9 Developing Business Policies

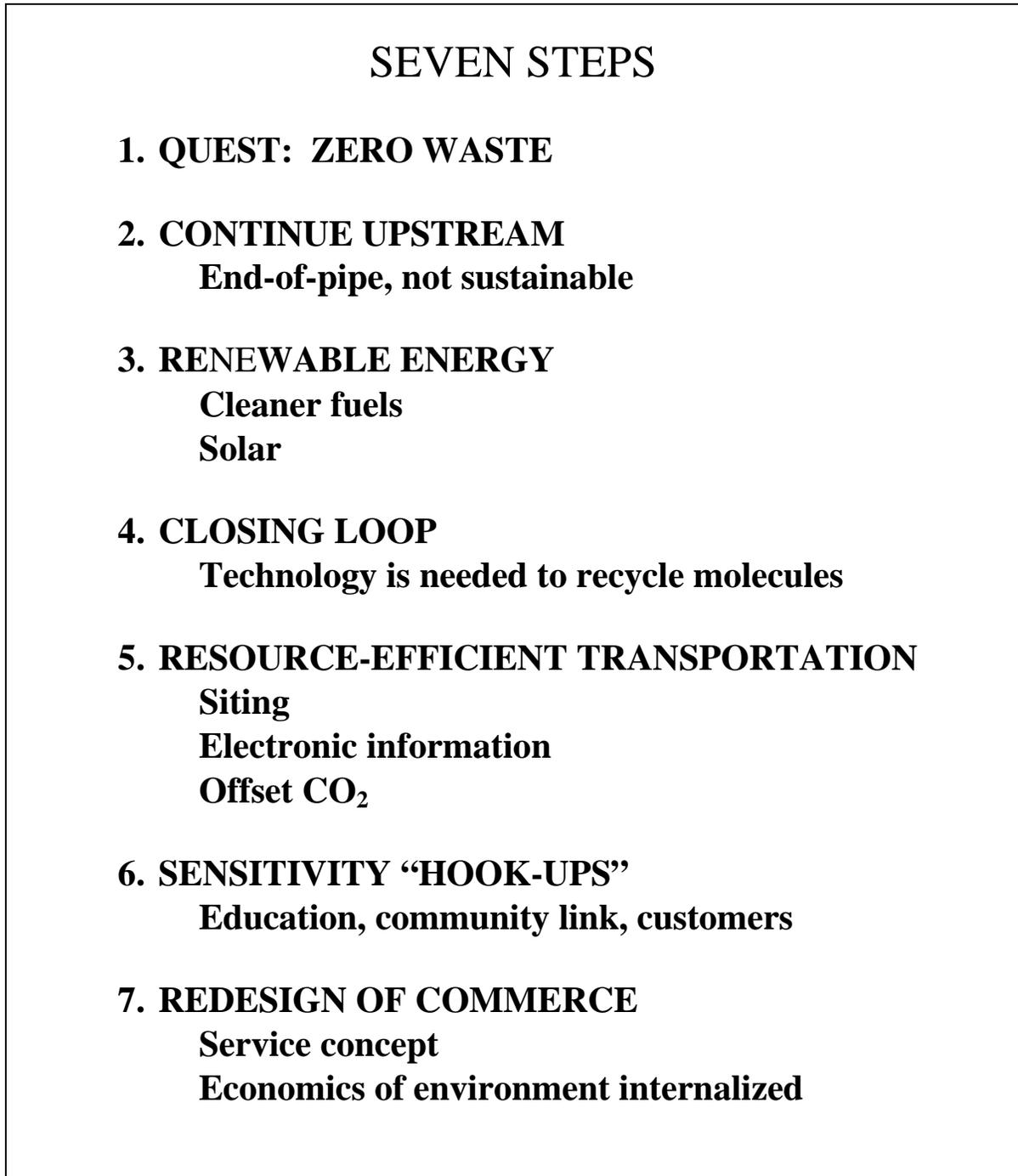


We are at the beginning of our environmental awareness within manufacturing companies. In-house product design teams now include environmental specialists to monitor the use of toxic chemicals, hazardous to workers or the public, or harmful to the climate and/or ecosystem. As a result of incentives from eco-labeling, recycling laws and package reduction rules, progressive companies are redesigning parts and products. Disassembly and material reuse are now important objectives to be optimized in design. Universities now teach “design for the environment” engineering courses.

Redesign of processes and products has longer lead time before environmental improvements can be recognized. Because redesign can lower energy use and reduce material requirements, greater environmental gains can be achieved. But similar to the incremental approach, environmental gains are slowed by population growth and expanding economies. Only through considering the systems responsible for energy flow in our global society can we come to an intelligent restructuring.

A few innovative companies have radically restructured to incorporate concepts they believe will sustain them in the next century. Motivated by a sincere concern for the environment and profits, these companies believe productivity and consumer preference are linked to their ecologically based performance. Taken from the operating principles of Interface, a building/office supply company operating out of Atlanta, Georgia in the U.S., Figure 10 lists seven steps guiding the company. Implementation requires the development of inventories, and establishing matrices and goals. It includes reorganization and retraining of employees. Ray Anderson, founder and CEO of Interface, recently reported at the Globe 98 Conference in Vancouver, Canada (March 1998), that setting the goal of zero waste has already had substantial returns by reduced disposal charges and inventory losses. In some cases companies have formed entirely different relationships with suppliers and their customers. However, to make this substantive rethinking and restructuring of companies more the norm, society has to change. We must reevaluate the indicators measuring success. Material comfort and financial status have been prime motivators in market-based economies. Developing equally important incentives for social harmony, total quality of life, and healthiness of our natural ecosystems will be the challenge for the next generation of econometric models.

Figure 10 Adapted from the operating principles of Interface (Atlanta, GA, US): Seven steps guiding the company.



8. Strategic Initiatives for Air Pollution Controls

TEPA recognizes the air pollution situation facing Taiwan. Seventy-five percent of the population lives in major urbanized and/or industrialized areas with PM₁₀ and O₃ pollution. Twenty percent of the population lives in the Taipei metropolitan area with air toxics pollution. Currently, about seven percent of population is exposed to unhealthy levels of PM₁₀ (125 $\mu\text{g} / \text{m}^3$) and/or O₃ (120 ppb) daily in Taiwan. Half of Taiwan's population is living in areas with yearly PM₁₀ concentrations averaged above 65 $\mu\text{g} / \text{m}^3$ in Taiwan. In these areas, air pollution exposures are dominated by mobile and stationary sources. In cities, air pollution health risks are determined, primarily, by particulate matter and air toxins. In areas downwind of cities, ozone is a growing concern and urban nitrogen dioxide emissions are believed to be the rate limiting pollutant.

In the southern portions of Taiwan, emissions from major industrial facilities are important but the community air pollutants are still characterized by particulate matter (PM), air toxins and ozone (O₃). Intermixed with residences are thousands of small commercial and industrial sources.

It is well known that its two main precursors, NO_x and hydrocarbons (HC) form urban O₃, through photochemical reactions. To determine ozone control strategies for the urban areas in the US, the US EPA has used the Empirical Kinetic Modeling Approach (EKMA) model. In the EKMA model, the urban ozone problems can be separated into HC-limited or NO_x-limited regions by specific HC/NO_x ratios. The HC-limited regions are where HC/NO_x ratios are smaller than 8:1. The NO_x-limited regions are where HC/NO_x ratios are greater than 8:1. The monitoring data of Taiwan show that HC/NO_x ratios are all greater than 8:1. Therefore, an O₃ control strategy must stress limiting NO_x emissions. Energy-intensive industrial sectors, such as petrochemical industries, and utility companies are two major stationary sources NO_x emissions. A sensible control strategy also needs to cut down NO_x emissions from mobile sources, such as motorcycles, cars and diesel buses and trucks (Chan and Hwang 1996).

Since the physical forms of air toxics are mostly vapors or aerosols, the control strategy for HC and PM₁₀ can also reduce emissions of air toxics. In addition, the air toxics are mostly related to the use of fossil fuels, such as coal and oils. Therefore, the ultimate solution to reduce long-term health risks associated with air toxics, such as benzene and polyaromatic hydrocarbons (PAHs), is also one which relies on alternative fuel policy.

Some receptor model studies have estimated the relationship between emissions and ambient concentrations. The contributions of emissions to ambient CO concentrations in Taipei are estimated to be 50-60% by 2-stroke motorcycles, 10-20% by 4-stroke motorcycles and another 10-20% by non-catalyst cars. The contributions of emissions to ambient NO_x concentrations in Taipei are estimated to be 30-40% by non-catalyst cars, 25-36% by diesel vehicles, 17-25% by catalyst cars, and another 10-15% by 4-stroke motorcycles. The contributions of emissions to ambient total HC concentrations in Taipei are estimated to be 25-60% by 2-stroke motorcycles, 26-43% by gasoline evaporation, and another 5-17% by diesel vehicles (Chan et al. 1996). It is worthwhile to note that uncertainty still exists in most source apportionment models. Therefore, more research and data are still needed in order to produce reliable quantitative estimation for the benefit of emission reduction from different source categories. This is true for both O₃ and PM₁₀ control policy in Taiwan.

To date, TEPA has followed a traditional model of controlling air pollution. By using emission limits, operating permits and clean fuel requirements, among others, direct emissions have been reduced. Conventional approaches have been supplemented with an economic incentive (pollution fees) and a technical assistance program. New strategies, however, need to be advanced that shift other agencies' perspectives. In the long run, to improve air quality, strategies that encompass factors leading to emissions have to be included. TEPA should consider material and energy flows upstream of sources as well as after-market factors.

Mindful of the four policy initiatives described in an earlier section, here we first propose a risk-based air quality goal for TEPA to track its performance, and then illustrate pollution control/prevention strategies for three important sectors: transportation, manufacturing and construction.

Risk-based Air Quality Goals

TEPA should set risks to human health and the environment as the ultimate guidelines to evaluate its control policy's performance. TEPA should develop the capability to better characterize the mortality and morbidity effects of PM and O₃. In addition, TEPA should identify pollutant components and mechanisms of PM toxicity in the Taiwanese population. Before risks can be determined, TEPA should establish exposure assessment as an intermediate tool to guide its policy. Therefore, the total exposure assessment on PM, O₃ and air toxics should be conducted systemically for the general population as a supplement to routine ambient air monitoring.

There is a particular need to develop air quality models for O₃ to guide control strategy developments. Photochemical Ambient Monitoring Stations (PAMS) should be established in central and southern Taiwan to monitor ozone precursors more closely. TEPA should also establish robust and economic methodologies to document emission factors of all sources. TEPA should also develop valid air quality models of PM and make them available for local regulatory agencies to use.

TEPA should assess environmental equity and effectiveness issues in its control policy. It should also apply state-of-the-art environmental communication methodology to address risks and inequity issues of air pollution to its constituencies, that is its citizens, communities, companies, NGOs, media, and legislators.

We recommend that TEPA to use outside resources to help carry out the above policies. Long-term contracts of 5 to 10 years with academic institutions to set up a "Center for Environmental Statistics" and a "Center for Risk Assessment" are needed in order to evaluate the program performance of TEPA's policies systemically and objectively. Another function of these two centers would be to educate and train current and future TEPA personnel on risk assessments in order to expand the Agency's technical capability in the future.

An Environmentally Sustainable Transportation Policy

We propose that TEPA adopt an environmentally sustainable transportation (EST) policy. Ideally, EST should consist of the following four components, i.e., a new generation of clean fuels, clean vehicles and clean route systems, and value change in individual travel behavior to reduce powered-transport demand. Detailed recommendations for each component of EST are discussed in the following sections.

Clean Fuels:

a. Expanding fuel quality regulation.

Urban air quality can be improved immediately by changing fuel quality. TEPA's schedule to phase out leaded gasoline by the year 2000 and to provide low sulfur diesel (<500 ppm) by the year 1999 is a correct fuel policy. Significant reduction in PM, VOC and air toxics can be gained by imposing low sulfur (< 80 ppm), low benzene and low aromatic standards for gasoline by the year 1999.

b. Develop an alternative fuel policy.

Compressed natural gas (CNG) is a feasible substitution for diesel. TEPA should invest APF in the construction of safe infrastructure for a CNG supply and for advancing the technology of a gasoline-CNG fuel engine project. An incentive-based mechanism should be established to convert current gasoline-powered and diesel-powered buses, trucks and garbage trucks to CNG-powered ones. TEPA should also coordinate with Ministry of Economic Affairs (MOEA), the Council of Agricultural Affairs (CAA), and the National Science Council (NSC) to set up a national bio-fuel project. Bio-fuels, derived from rice, wheat and corn, can benefit urban air quality by reducing PM and VOC emissions. This bio-fuel project will be particularly relevant to situations where free trade of agricultural products are in effect after Taiwan joins in the World Trade Organization (WTO). The bio-fuel project could make significant ecological, economic and social contributions to Taiwan.

Clean Vehicles:

- a. The National Electric Vehicle (NEV) project is an option for reducing emissions in the future. The project should emphasize technology to manufacture electric motorcycles and batteries. Investment should also be made on building infrastructure for recharging networks and battery recycling systems for these vehicles.
- b. A retrofit program can largely reduce emissions from in-use heavy-duty vehicles. A regulation should be established to enforce the application of particle filters for buses and trucks. A PM emission standard for vehicles should be established.
- c. A pollution-based classification system should be applied to passenger cars and motorcycles in metropolitan areas. Remote sensing could be used to help classify the emissions from passenger cars and motorcycles. Information on vehicle classification should be used to inform the public and control traffic flows.

Clean Routes and Behavioral Changes:

- a. TEPA should work with national and local transportation authorities to create a clean and convenient public transportation network. Subsidy to local governments for lowering the price of public transportation should be continued in order to increase ridership. Financial support should also be available to fund re-routing and redesign of bus lines in order to connect bus routes and rail routes.
- b. TEPA should start planning to build a well-connected island-wide "people's route" used by non-powered transportation vehicles and sport utilities. This will provide an additional recreational facility for Taiwanese people as well as an educational opportunity to change value of travel for the next generation.
- c. TEPA should establish a "rideshare" commuting program to reduce the number of drivers and vehicle kilometers traveled (VKT) for companies and institutions in areas with serious air pollution problems. The program must include a survey of employees about the commuting habits and provide incentives to change from private vehicles to public

transportation tools. Several steps can be taken by companies to create positive incentives for change, such as: make public-transit passes available, encourage car-pooling, provide shuttle services, and provide showers and racks for cyclists. Another positive incentive is to allow trades between mobile to stationary emissions for individual companies.

An Eco-Efficient Policy for Construction Industry

The construction industry has long been overlooked by TEPA as an important economic sector in the creation and solution of air pollution in Taiwan. Construction sites are recognized as an emission source of air pollution and levied with air pollution fees, which are based on areas under construction and duration. This policy has the potential to affect only a small percentage of the emissions represented by any construction project throughout its life cycle. Construction of buildings, homes and other types of structures will influence transportation demand and energy consumption. Architectural design will determine energy consumption of the built structure. Specification of materials (building components, furnishings) in turn create the demand for raw materials, transport and manufacturing.

TEPA should consider simple and easily implemented steps first. Requiring recycled material content in buildings could reduce emissions while creating a market for recycled materials. Setting limits or establishing a performance goal for the off gassing of volatile organic compounds from products would have effects on indoor air quality and cut primary emissions in manufacturing.

TEPA should create a government-industry partnership program to bring architects, developers and construction companies together to develop ecologically friendly construction materials and technologies. Life-cycle assessment (LCA) is an analysis tool used primarily to assess the external impacts of specific products. There has been limited experience in applying LCA to evaluate buildings, roads or larger developments. Applications in Taiwan would require considerable effort to customize inputs for local suppliers. The basic methodology, however, does provide the framework to guide Taiwan's specific research. Promoting LCA prompts academic and private sector cooperation, and eventually will provide guidance to ecological

design. TEPA should create a public-private jointly sponsored "Center for Building Sciences" to carry out these missions.

TEPA should create incentives for architects and developers to design ecological buildings. As a suggestion, architects might derive a portion of their fees based on the actual operational efficiency of the buildings they design. Being developed and tested currently are building performance criteria to quantify sustainable design aspects. Life cycle assessment (LCA) work on products is being extended to evaluate environmental consequences of building construction and community developments. LCA could eventually extend incentives to carbon dioxide emission reductions or resource preservation. TEPA should also coordinate with financial institutions to consider operational costs for buildings and offer incentives like larger mortgages or reduced interest for more efficient buildings.

TEPA should use air pollution fees collected from construction sites to finance various demonstration projects of sustainable construction, which can provide the pivotal functions of personnel training, skill and tool development and public awareness.

An Eco-Innovation Driven Industrial Policy

Manufacturers are obvious targets for air pollution reductions. Traditional pollution control programs look at just the source and not the entire material and product stream. Manufacturers have relationships to suppliers and their downstream customers. TEPA could develop strategies to integrate these relationships vertically along the product manufacturing line as an emission "food-chain" group. And then, TEPA can set a total emission limit for each group of companies. Companies might get relief from air pollution fees or emission limits for emission reduction by their suppliers or secondary manufacturers. Large industries might use their technical expertise to assist domestic customers/suppliers in cutting pollution. We recommend that TEPA apply this policy first to the petrochemical industries to cut down on NO_x, SO_x, VOC and CO₂ emissions. TEPA should assist in developing emission-auditing technology and low-NO_x burners for these industry. This policy can also apply to semi-conductor and biotechnology industries in order to

cut down CO₂ and air toxics emissions. TEPA should assist in developing energy-efficient cleaning technology for this sector.

TEPA should use global warming issue to persuade the Executive Yuan to perform environmental impact assessment on economic development policies in the future. TEPA should lobby the Legislative Yuan to incorporate government development policy into an environmental impact assessment act as an assessment entity. TEPA should also propose and lobby to expand its administrative authority to become a ministry in charge of energy-environment issues.

9. Strategy Plan for Air Pollution Research

Because TEPA is a regulatory agency, the role TEPA should play in sponsoring and conducting research is usually directed towards solving problems related to the administration. However, we are also aware that science and technology play an unusual role in environmental policy (Moltke 1996). In Moltke's words, "environmental policy rests on a foundation of scientific research without which it would not even exist". In order to better understand current pollution problems and anticipate future environmental problems with less uncertainty, we recommend that TEPA continue sponsoring core research. The core research must target developing methodology, understanding biological/ecological mechanisms, and systematically acquiring environmental data. In our strategic plan for air pollution research, we have tried to balance the problem-driven research with the core research in the proposed research agenda.

In the field of air pollution research, we propose that TEPA should use a hierarchy of mission-goal-agenda as the basic framework to design research topics. First, TEPA needs to establish a few research missions, which are preferably related to its control strategy. Second, TEPA should then delineate specific research goals in order to fulfill its missions. Lastly, TEPA should propose certain high-priority research and development (R&D) topics in order to provide scientific foundation to support its policy tools. For each research topic, TEPA should specify the expected research product and potential use in advance. We believe this is the best way that TEPA can maximize the utilization of its R&D results.

At the same time, TEPA should revise its research management practices in order to adjust to the new research agenda proposed in this report. The current practice of transferring air pollution fee for research from TEPA to National Science Council (NSC) does not work in the way TEPA has expected because NSC does not provide enough manpower to adequately manage the research fund. Another problem is that NSC does not assume equal responsibility of assuring APF's success, which presumably should be with the shift of research funds. One solution is that TEPA can liberalize the managing contract of its research fund from NSC in order to improve efficiency. In addition to NSC, the universities, institutions and non-governmental organizations in Taiwan should be allowed to bid for managing the research fund for TEPA. The research

topic list in this report can serve as TEPA's basic requirements in the agreement for its future contractors. The other solution is to bring the research fund back to TEPA and expand the role and manpower of its R&D office to accommodate the new responsibility. This recommendation can clarify and simplify the line of responsibility for APF. TEPA also needs to realize that most research topics take more than one year to complete. Therefore, there is a fundamental need to design multi-year projects in order to achieve highest research excellence. Current single-year research project should be largely reduced. Along with prolonging the research period, TEPA should simplify mid-term reports. Instead, TEPA should focus more on the process of quality control, data management and thorough reviews of the final report. Further funding for researchers and research groups should be tied to their achievements and completeness on previous projects. For some studies where there are currently no domestic expertise or for studies that could be more effectively done by researchers in other countries, we recommend that the TEPA encourage international research teams to initiate research projects. We believe internationalization of environmental studies can eventually lead to many benefits for Taiwan's academic development, environmental policy, and environmental quality.

In the following sections, we present a detailed list of 4 missions, 14 goals and 41 topics for air pollution research in Taiwan.

R&D Missions

We recommend TEPA to focus its air pollution research on the following 4 missions:

Mission 1: Perform research and development to identify, understand, and anticipate current and future air pollution problems.

Mission 2: Provide technical support for environmentally sustainable transportation policy.

Mission 3: Provide scientific basis for eco-innovated manufacturing industry.

Mission 4: Provide leadership in advancing eco-efficient construction technology.

R&D Goals

We proposed several research goals that will help TEPA to fulfill individual missions in the following:

- Goal 1: To develop approaches to characterize risks to human health and environment.
- Goal 2: To develop regional air quality models.
- Goal 3: To develop methodology to assess environmental equity and effectiveness issues.
- Goal 4: To establish an alternative-fuel technology program.
- Goal 5: To complete a comprehensive impact assessment project on the environmental health and safety issues of compressed natural gas (CNG) utilization.
- Goal 6: To develop a technological foundation for clean production of electric vehicles and batteries.
- Goal 7: To develop technology for building cleaner and smarter transportation routes.
- Goal 8: To develop pollution prevention technology needed for integrating petrochemical industries vertically.
- Goal 9: To develop energy-efficient industrial design technology.
- Goal 10: To development total environmental auditing modules for an individual plant.
- Goal 11: To develop global warming related industrial technology and policy.
- Goal 12: To provide scientific basis for green construction codes.
- Goal 13: To develop eco-friendly technology of building materials.
- Goal 14: To develop energy-efficient technology for building's cooling and lighting.

Proposed High-Priority Research

Following is a list of 41 high-priority research topics for the 14 proposed research goals.

GOAL 1: To develop approaches to characterize risks to human health and environment.

| Research Topic | Product | Use |
|---|---|---|
| Conduct epidemiological studies on mortality and morbidity of PM and O ₃ . | Quantify "exposure-effects" slopes. | Support NAAQS revisions. |
| Conduct in-vitro and in-vivo PM and O ₃ toxicity studies | Illuminate toxic mechanisms and "dose-response" | Identify responsible elements for particle toxicity |
| Conduct studies on crop and forest damages of O ₃ | Quantify ecological risks of O ₃ pollution | Provide estimation of welfare effects by O ₃ pollution |
| Conduct exposure assessment on PM, O ₃ , and air toxics | Develop instruments and method to verify epidemiology studies | Assist development of regulation and control strategy |

GOAL 2: To develop regional air quality models.

| Research Topic | Product | Use |
|--|--|--|
| Develop Urban Airshed Model (UAM) | Customize computer modules for regional O ₃ modeling | Assist decision on NO _x -driven or VOC-driven O ₃ control strategy |
| Establish photochemical assessment monitoring system | Obtain comprehensive and representative data of O ₃ , NO _x , and VOC | Refine control strategy of O ₃ pollution |
| Develop receptor models for PM and air toxics | Customize computer modules for regional air quality planning | Assist source apportionment for regulatory purposes |
| Develop Taiwanese dispersion models | Customize computer modules for air quality modeling | Assist emission permits and environmental impact assessments |

GOAL 3: To develop methodology to assess environmental equity and effectiveness issues.

| Research Topic | Product | Use |
|---|--|---|
| Conduct environmental justice study on air pollution | Delineate inequity problems of air pollution for under-privileged population | Assist in forming feasible environmental agreements |
| Conduct risk perception and risk communication studies on air pollution | Detect environmental spectrums of TEPA's constituencies | Help TEPA formulate better environmental education programs |
| Conduct environmental effectiveness study on air pollution fee | Differentiate environmental effects from fiscal or cost-covering effectiveness | Help link policy process to evaluation procedure for APF policy |
| Conduct competitiveness studies on domestic and international economy | Illustrate APF's impact on trade and investment in Taiwan | Provide data for TEPA to change fee collection system of APF |
| Conduct studies on single green tax policy | Illustrate relative role of green tax in the overall tax framework | Provide data for TEPA to change APF policy |

GOAL 4: To establish an alternative-fuel technology program.

| Research Topic | Product | Use |
|--|--|---|
| Conduct studies on transporting bio-fuel with fossil fuel in current pipelines | Extend current pipeline capability to transporting oxygen-based fuels | Increase policy feasibility of fuel transformation |
| Conduct pilot plant studies on processing bio-fuels (corn, sugar ad others) | Establish technical capability of manufacturing non-fuel energy in Taiwan | Provide technical infrastructure for TEPA's alternative fuel policy |
| Conduct studies on characterizing emissions from alternative fuels | Provide data of toxicity and ozone-forming capability of alternative fuels | Assist in promulgating national product standards for alternative fuels |

GOAL 5: To complete a comprehensive impact assessment project on the environmental health and safety issues of compressed natural gas (CNG) utilization.

| Research Topic | Product | Use |
|--|---|---|
| Conduct studies on health and safety of CNG's storage and distribution | Identify potential safe geographical areas for CNG utilization | Assist in promulgating facility standards for CNG application |
| Conduct studies on retrofit technology for bus, truck and garbage trucks | Establish retrofit kits for converting existing vehicles to be powered by CNG | Assist in the CNG policy to control mobile emissions |
| Conduct studies on manufacturing dual-fuel passenger vehicles | Establish domestic clean car technology | Increase technical and political feasibility for the CNG policy |

GOAL 6: To develop technological foundation for clean production of electric vehicles and batteries.

| Research Topic | Product | Use |
|--|--|---|
| Conduct studies on cleaner battery manufacturing and recycling technology | Establish economical and technical capability for battery supply | Increase political feasibility of electric car policy |
| Conduct studies on recharging technology and networks for electric motorcycles | Provide modules and infrastructure for convenient recharge | Increase consumer's acceptability for electric vehicles |
| Participate and lead in the national electric vehicle project | Produce 100% domestically built electric motorcycles | Prioritize electric vehicle types for most environmental benefits |
| Conduct studies on low-NO _x and low CO ₂ electricity generation technology | Develop burners with low environmental impacts | Reduce losses in regional air quality for electric vehicle's policy |

GOAL 7: To develop technology for building cleaner and smarter transportation routes.

| Research Topic | Product | Use |
|---|---|---|
| Conduct studies on electrically controlled highway toll system | Establish tools for rationing traffic flows by vehicle's emissions | Decrease vehicle miles traveled by dirty cars |
| Conduct studies on a national route network for non-powered transportation | Establish a building framework for an island-wide green route | Provide alternative mobile modes and values for car-bound society |
| Conduct studies to improve home to work and school public transportation system | Establish linkage of public transportation system across administrative lines | Reduce the car-dependent commutes |

GOAL 8: To develop pollution prevention technology needed for integrating petrochemical industries vertically.

| Research Topic | Product | Use |
|---|--|---|
| Conduct studies on life-cycle analysis for chemicals with high volume usage | Establish linkage of pollutant emissions between upstream and downstream | Assist vertically integrated control strategy |
| Develop monitoring and inventory methods for pollution prevention | Establish data collection mechanism for auditing performance of prevention | Help shift regulatory targets from end-of-pipe to materials and process |

GOAL 9: To develop energy-efficient industrial design technology.

| Research Topic | Product | Use |
|---|--|--|
| Conduct studies on designing energy-efficient clean rooms | Develop a laboratory and computer models for clean rooms | Help stabilize increase in pollution emissions from high and bio technique |

GOAL 10: To development total environmental auditing modules for an individual plant.

| Research Topic | Product | Use |
|---|---|---|
| Conduct studies on budgeting methods for energy consumption and emissions for an individual plant's mobile and stationary sources | Establish a computer model to trace mobile and stationary sources for a plant | Assist in cross-source emission trading policy for a regulated entity |

GOAL 11: To develop global warming related industrial technology and policy.

| Research Topic | Product | Use |
|--|---|---|
| Conduct studies on re-structuring energy and development policies | Develop national sustainability blue plans | Help meet the agreement of Kyoto Convention |
| Conduct studies on CO ₂ treatment technology | Develop CO ₂ -fixation technology for industries | Help reduce CO ₂ emissions from industries |
| Conduct studies on the reduction of non-CO ₂ greenhouse gases | Develop methods for monitoring GHGs in the field | Help reduce total emissions of GHGs |
| Sponsor workshop on global warming issues in Asia-Pacific regions | Develop international outreach programs for environment | Help solve world environmental problems via cooperation |

GOAL 12: To provide scientific basis for green construction codes.

| Research Topic | Product | Use |
|--|--|--|
| Conduct studies on total quality management of construction companies | Establish performance indicators of green construction codes | Reduce air pollution from building and operating construction projects |
| Conduct studies on energy efficiency for laboratory-type institutional buildings | Identify energy-saving potential for laboratories, hospitals, department stores, supermarkets, and wholesale centers | Reduce electricity-related air pollution from operating energy-intensive buildings |
| Conduct studies on energy-efficiency for housing complex | Identify energy-saving potential for apartments in housing complex | Reduce electricity-related air pollution from operating apartments |
| Conduct studies on energy-efficiency for high-rise buildings | Identify energy-saving potential for apartments in high-rise buildings | Reduce electricity-related air pollution from operating high-rise buildings |

GOAL 13: To develop eco-friendly technology of building materials and designs.

| Research Topic | Product | Use |
|--|--|--|
| Conduct studies on energy-saving building design and materials in tropical weather | Produce green model buildings for demonstration | Provide guidelines of building design and materials selection for developers and consumers |
| Conduct studies on renovation technology for housing projects | To develop design software retrofit technology for existing houses | Reduce electricity-related air pollution by saving energy consumption of existing houses |

GOAL 14: To develop energy-efficient technology for building's cooling and lighting.

| Research Topic | Product | Use |
|--|--|---|
| Conduct studies on improvements in cooling and lighting technology | Set up a center for indoor climate research center | Provide technology of building healthy apartments and buildings |

Epilogue and Acknowledgement

Before I (Dr. Chan) came to join in the 1997-1998 Takemi Program, I was called upon to prepare a strategic plan for air pollution research and control in Taiwan by the Taiwan EPA (TEPA). This requirement made me change my original Takemi research topic of "Comparative Health Risk Assessment of Air Pollution among Countries" to "Strategic Planning for Air Pollution Research and Control in Taiwan." Although the subject is still in the research domain of environmental health in general, the research methodology needed is quite different between these two projects. The former one is usually approached by the disciplines of quantitative health risk assessments and physical sciences. Such a method plays only a portion of the knowledge spectrum needed to study the later subject. This is really a challenge for the authors, who are more comfortable with writing technical papers than the policy papers. However, the project has been successfully carried out with the help of resourceful academic environment in the Takemi Program of Harvard School of Public Health and the wider campus of Harvard University. We would like to thank Professor Michael Reich, director of Takemi Program and Department of Population and International Health, for his strong support in this study. We also want to thank all of Takemi fellows for their frequent exchange of viewpoints on various useful and important issues related to this study. We also want to thank the other sponsors of Dr. Chan's affiliation with Harvard this year, the Fulbright Foundation, the National Science Council of Taiwan and the Taiwan Environmental Protection Agency.

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