

## **Current and Future Prospects for Modern Solid Waste Management in the Developing Countries of East Asia**

Jack Fritz and William Gillen  
East Asia and Pacific Region  
The World Bank

### ***Introduction***

Today's media is filled with headlines about real and perceived financial meltdowns in Asia and the impacts on our stock portfolios. But the real, long term impacts will fall on the region's poor and the development process in general. From the standpoint of environmental management in the region, we are beginning to see some slackening in what was a brisk pace confronting a range of issues, including improvements in solid waste management. Many of these efforts have been temporarily shelved as funds are earmarked for social safety nets and financial reform. On the positive side, the quantities of residues produced, in particular industrial wastes, have abated somewhat as economic activities slow. Another example is reduced vehicle pollution on the one hand but increased illegal toxic waste dumping on the other. Nevertheless, solid waste management in many large urban areas such as Manila, Bangkok, Jakarta and large cities in China, have been in crisis for some time.

Special circumstances have brought this crisis to the attention of urban managers. Traditionally, urban residential wastes have been informally recycled by the poor thereby providing a reasonable income when compared to construction work, often considered the yardstick. What is left over after recycling is usually dumped at a large number of informal sites around the suburban periphery. In the case of Beijing, for example, there were some 4000 small dumps located around the city before the development of a new landfill financed by the World Bank. In addition, the market for recycled materials from the developed countries has slowed considerably as imported recycled materials flood local markets.

A second consideration is the fact that many of these peripheral areas which formerly were farmlands or waste lands are now valuable as the cities expand. Again, in Beijing, cleanup of these dumps has been going on for some years and the sale of these properties far exceeds the cost of clean-ups.

A third factor is that many of the informal dumps have caused seriously polluted aquifers which feed local wells since piped water is not yet available in suburban areas. Water shortages in North China, for example, are another factor which requires improved waste disposal techniques so as not to pollute groundwater

Increasing prosperity, prior to the current financial crisis, has also changed the composition of waste and its per capita production. A few years ago, it was roughly 0.5

kg/cap/d and today it is roughly 0.9 kg/cap/d in most urban areas of East Asia. Also, the rush to privatize environmental service infrastructure has prompted urban managers to seek innovative solutions to solid waste management which will provide for some level of cost recovery. However, this has not progressed very far to date.

Finally, with increasing opposition to the siting of incinerators in Europe and North America, suppliers of these systems have been looking at East Asia as a potential market. As a general proposition this is fine, but on closer examination of the technical, financial and institutional feasibility in many countries, this is questionable at this point in time.

### ***Incineration as a Solution***

Incineration is traditionally seen as an effective method for treatment of municipal solid waste; however, compared with direct disposal, it is relatively expensive and complex. The main advantage of incineration is the large reduction in volume and weight for final disposal, hence less requirements for land, and the potential heat energy released from the combustion processes can be used for power generation, district heating and/or industrial purposes. Among the main constraint of incineration of solid waste is high investment and operating costs and demand for highly skilled operators and maintenance crews, and expensive control measures to prevent air pollution. Inadequate institutional and management capacity in many Asian cities to operate, control and monitor incinerators are of concern.

Decision makers often mention incineration as the ultimate solution for disposal of solid waste compared to other, less complete approaches such as landfilling, recycling and composting. It is the method in many countries, which they would like to be technologically compared with. The required financial and technological commitments of incineration are often poorly understood by decision makers and not always built on objective facts. A decision to install an incinerator based on wrong information may therefore be financially and operationally ruinous.

An incinerator for solid waste should be viewed as a thermal power plant which uses waste as its fuel and is therefore highly dependent on the calorific value of that fuel as well as varying refuse characteristics. Generally, the calorific value of urban solid waste in East Asia is very low due to high moisture and inorganics content. In fact, it will probably not burn without auxiliary fuel, a cost item which cannot be accurately predicted. In order for refuse to burn it should not have a heating value below 6 MJ/kg; most refuse in Asia is half this value. The assumed benefit and accompanying revenue stream from electricity via a boiler/steam turbine generator or energy is not technically feasible when burning very low calorific value refuse.

Planning for such a system must accompany a year round refuse analysis to establish heating value as well as proximate and ultimate analyses (used to determine the constituents of typical solid fuels). In addition, a complete mass and heat balance

showing that the process is feasible is required. This balance needs to be analyzed by specialists familiar with combustion, power plants, boilers and the like.

Incinerators for solid waste in Japan, the US and Europe operate relatively well because of the high calorific value of the waste, its low moisture and low inorganics content. On the other hand, some incinerators built in developing countries have not operated and stand idle. Examples can be found in New Delhi and Lagos. These units were provided through bilateral aid programs and there was little technical analysis done to assure that they would function as specified.

Additional issues arise because of air pollution considerations but these are often exaggerated. A well-operated, modern incinerator with air pollution control does not necessarily pose an extraordinary threat to the public. Proper disposal of residuals (slag and residuals from fluegas cleaning) is another concern and requires a secure landfill depending on the type of residuals and its leaching characteristics.

Any municipality which commits to incineration must be able to provide refuse on a continual basis, guaranteeing its calorific value and keeping the unit operating at peak efficiency in order to meet environmental guidelines.

Finally, the operation of large incinerators requires specially-trained personnel generally not found among municipal operations staff. Rather, these people tend to come from the process industries or the power sector. For this reason, some countries have involved the private sector. Both the public and the private sectors protect their interests through a host of binding legal contracts such as power purchasing agreements, take or pay contracts for the waste and availability of landfill space for residuals. These arrangements are similar to those being put in place for the power sector. Whether this type of arrangement can work in the solid waste management sector in East Asia has also not been proved.

Hence, there has been an urgent need for a decision-makers' guide for incineration of solid waste that can give substantial advice to municipal managers on whether or not to consider incineration of solid waste. This is often repeated at various meetings held throughout the region. The World Bank is now drafting this decision-makers' guide with assessment of technology; operation issues; environmental issues; institutional and management requirements; financial and cost aspects; and social-cultural constraints.

### ***Incineration Advantages***

Incineration is the most efficient way of reducing the waste volume and demand for landfill space. Incineration plants can be located close to the center of the wasteshed, reducing the cost of transportation. Ash from the incinerators may partly be reused for back filling and construction purposes or disposed of with a minimum of environmental protection measures. Energy may be recovered for heat or electric power.

Irrespective of the treatment method applied (incineration, biological treatment or decomposition in a landfill), the organic contents of waste will in time turn into CO<sub>2</sub> and water vapor. The energy from waste incineration substitutes energy produced from fossil fuels, consequently reducing the consumption of, and pollution from, fossil fuels. Therefore, energy recovery from waste is practically CO<sub>2</sub> neutral, reducing the emissions of greenhouse gases.

Waste incineration may be particularly advantageous in cases where siting of a landfill is impossible or problematic due to a lack of suitable sites or long hauling distances, resulting in high costs of landfilling.

### ***Incineration Disadvantages***

An incineration plant involves heavy investment and high operating costs and requires both local and foreign currency throughout its operating life. The resulting increase in waste treatment costs will serve as an incentive for the waste generators to seek alternative possibilities of waste disposal. Furthermore, waste incineration is only applicable if certain requirements of the waste are fulfilled, and in this respect, the composition of the waste in low to middle income countries is marginal. An incineration plant is complicated and requires skilled staff for satisfactory operation and maintenance and the residues from the flue gas cleaning must be disposed of in controlled and well-operated landfills to prevent ground and surface water pollution.

Therefore, solid waste incineration projects are only feasible if the following criteria are fulfilled:

- A mature and well-functioning waste management system has been in place for a number of years.
- Solid waste is currently disposed of at controlled and well-operated landfills.
- The supply of combustible waste will be stable and amount to at least 50,000 tons/year.
- The waste fulfills the minimum criteria for fuel combustibility of 6 MJ/kg, throughout the seasons, with an average value of not less than 7 MJ/kg.
- The community is willing to absorb the increased treatment cost through treatment charges and tax-based subsidies.
- Skilled staff can be recruited and maintained.
- The planning environment of the community is sufficiently stable to allow for a planning horizon of 15 years or more.

### ***The Waste Sector***

A developed and controlled waste management system is considered a necessary prerequisite to incineration. Waste, on one hand, is considered a nuisance by its generators, who want to be rid of it at little cost. On the other hand, many of the poor,

working formally or informally with waste collection, transportation, recycling and disposal, seek to maximize their profit or to create a living.

Existing regulations and enforcement must therefore be highly efficient to ensure that all waste which cannot be recycled is ultimately disposed of at controlled and well-operated landfills. This must be the case for both municipal solid waste, generally dealt with through public waste management systems. Overall control of the waste flow, including industrial waste, is very important in order to ensure reliable supply for incineration. The maturity of a solid waste management system can to some extent be assessed by the level of integration of organizations involved in solid waste management, the presence of environmentally controlled landfills and full implementation of the polluter-pays-principle in the waste sector. The latter means that the full costs of operating the waste management systems is acceptable to and paid for by the various waste generators – directly or indirectly. The waste charge structure must ensure optimum use of and balance between the different waste management facilities (e.g. incineration plant and landfills).

Public awareness campaigns emphasizing waste minimization, recycling and proper waste management are also part of a mature waste management system.

### ***The Energy Sector***

Incineration of solid waste is significantly more expensive than controlled landfilling, roughly double to triple the cost on a per ton basis. Minimization of the cost through sale of energy recovered is therefore essential to the economic feasibility of the plant. The institutional and economic characteristics of the energy sector are important when considering introducing an incineration plant. The primary question which arises is the feasible end use of the energy produced: district heating, steam, electricity or any combination.

Sale of energy in the form of hot water for district heating purposes, or, in particular cases, low pressure steam to large-scale industrial consumers nearby provided that sufficient contracts and guarantees can be arranged, results in the lowest costs of construction for the plant and a high percentage of energy recovery. Sale of combined power and heat or steam results in an equivalently high degree of energy recovery, but the cost and complexity of the plant are increased.

The energy sector is often heavily regulated. Concessions to produce and sell electricity are generally granted to a limited number of public and private operators only. An incineration plant established by another authority or a private organization may thus encounter difficulties before the necessary approvals and agreements are in place. Early cooperation with end user organizations is therefore important.

The most feasible organizational arrangement exists when the energy can be sold to one single consumer for own use or re-sale. The consumer may be a utility company with an existing distribution network.

Energy prices are often subject to taxation or are partly subsidized. Pricing may therefore be a political issue requiring a government decision. Also, in most developed countries energy prices are controlled by fiscal measures in order to favor energy production based on indigenous fuels.

Political and socioeconomic considerations play an important role when fixing the price of waste-generated energy. A high price resulting in a reduction of the waste treatment charges favor the waste sector whereas low energy prices favor the energy consumers.

### ***Community Issues***

The community and NGOs in the area where a new incineration plant is to be established are usually very concerned about possible negative environmental impacts. This concern may arise from lack of knowledge, general resistance toward change and fear of the unknown, such as higher waste charges or loss of subsistence for recyclers. Public awareness campaigns initiated in the early planning stages will serve to alleviate this concern. Furthermore, a detailed description of environmental protection measures included in the project is necessary not only with the environmental authorities but also with the organized NGOs.

During the design phase, the environmental authorities should establish standards for plant emissions and handling of residues. In the operational phase, the same authorities will control and enforce those standards. Public concern may be somewhat less if the environmental authorities and those entities operating the incineration plant are independent.

### ***Ownership And Operation***

The large number of stakeholders around an incineration plant will result in people and institutions having diverging and possibly conflicting interests. Depending on ownership, institutional borderline problems may arise regarding delivery of a sufficient quantity and quality of waste, the pattern and price of sale of energy, or both, especially when private ownership and operation is involved. Borderline problems must be solved at an early stage through detailed long-term agreements, as is the case in the power sector. Key agreements are those related to waste supply and energy sale.

Normally, public ownership of an incineration plant, as an economic entity, may be preferable especially in light of the need for authority control and monitoring as well as integration of all solid waste activities and borderline problems. Irrespective of whether the plant is publicly or privately owned/operated, the authorities will have to guarantee to

cover the annual capital and operating costs. This will be a problem if the income from energy sale and waste charges fails to reach the budgeted amount. The reasons for the shortfall could be insufficient waste supply, lower calorific value than assumed or reduced energy prices or waste charges. Ultimately, the economic risk will rest with the community where the plant is established, since the private operator can leave.

Operation and maintenance of the plant requires skilled managers, operators and maintenance staff. Recruiting and maintaining the staff are therefore important issues. The skills required are similar to those of independent power plants. However, all or part of the operation and maintenance of the plant can be sub-contracted to private companies with long-standing practical experience.

World-wide, there are only a limited number of experienced manufacturers of equipment for incineration plants. Spares and consumables must therefore to some extent be imported. Hence, foreign currency will be needed not only in order to construct the plant but also during the period of operation. Plant operations must therefore be organized with unhindered access to procurement of spares and services paid for in both local and foreign currency.

### ***Waste As Fuel***

The most crucial factor for the feasibility of an incineration plant is the nature of the waste and its calorific value. If the mandatory criteria for waste combustibility are not fulfilled, the project should be terminated immediately. Unfortunately, as a result of the socioeconomic situation in many low to middle income countries, only limited amounts of useful resources are wasted. Organized and informal recycling activities everywhere in the waste handling system tend to further reduce the amount of highly combustible materials such as paper, cardboard and certain types of plastic in the waste. Additionally, the waste may exhibit high ash and moisture content. In areas dominated by high humidity or heavy showers, closed containers for collection and transportation should be used to avoid a significant increase of the water content of the waste. Some industrial and also commercial and institutional wastes (except from market waste) tend to have a significantly higher calorific value than domestic waste. An appropriate mix of wastes may therefore make incineration possible. Strong management of the collection system is, however, required to maintain segregated collection.

Introduction of advanced waste treatment like incineration will have a significant impact on existing informal recycling activities. Scavengers in the downstream end of the waste collection and disposal system will lose their source of income. Even though efforts are made to compensate these people for their loss of income, some of them will shift to the early stages of the handling system. This may alter the composition and combustibility of waste arriving at an incineration plant. It is generally difficult to keep recyclers away from their source of income. The waste survey must therefore account for the existing waste composition and calorific value and for expected changes during the adopted planning period. Annual variations must be carefully surveyed and assessed.

## ***Financial Issues***

Incineration is an advanced waste treatment technology, costly to implement, operate and maintain. A significant amount of foreign currency must be available for the initial procurement of equipment and spares, and later on for replenishing stocks of spares and for expatriate managed plant overhauls. Incineration units are designed with a capacity limit of about 20-30 tons/h. 10-20 tons/h is recommended. Whenever such capacity is exceeded, another unit must be introduced. This causes discontinuities of the curve when plant investments are plotted against annual capacity.

The investment in such a plant depends to a great extent on the required form of energy output. The least expensive plants are those equipped with hot water boilers only. Production of steam and electricity make the investments in mechanical plant and civil works much higher (in total about 40%). The operating costs are also higher for electricity producing facilities.

The net treatment costs of an incineration plant are rather sensitive to fluctuations in the quantity of waste treated and in the quality of the fuel. Waste with a lower calorific value of 6 MJ/kg has a net treatment cost which is 30% above that of waste with a heat content of 9 MJ/kg. If the plant, due to a shortage of waste or extended periods of maintenance, processes only 2/3 of the design load, the treatment cost almost doubles. Any forecast of the net costs of incineration should be made on the conservative side and accompanied by a sensitivity/risk analysis. It must be remembered that the economic risk, even for fully privatized plants, will end up with the municipality serviced by the plant.

The net cost of incineration is significantly higher than for landfills established according to the strictest environmental standards. From a rigorous economic point of view it is often difficult to justify the increased costs of waste disposal in most developing countries. A full cost benefit analysis is therefore required to assess whether the locally obtainable benefits are considered sufficient to balance the costs.

Recovering the costs of an incineration plant in low to medium income countries is rather difficult. Depending on the family size, each household may easily generate 1-2 tons of waste for incineration annually. The net incineration charge will therefore amount to at least \$50-100/year per household. It is important to assess the ability as well as the willingness of the serviced population to pay such a charge in addition to the cost of collection and transportation.

The cost of incineration may be recovered through a combination of a gate charge, usually paid by trade and industry and a connection charge levied on the entire community. The connection charge may be collected directly as a waste management charge or as a surcharge on the electricity or the water bill. However, these utilities are usually loathe to include such a charge on their bill. The charges may, however, become

so great that the normal market mechanisms and/or waste disposal system are distorted. It may therefore be required to subsidize the plant via the budget of the municipality. Otherwise strict enforcement may be required to ensure that all waste is taken to the incineration plant rather than disposed of indiscriminately.

It is important to design an affordable and publicly acceptable tariff policy, which ensures sufficient income for continued operation, management and development of the plant as well as a suitable waste flow matching the processing capacity of the plant. Various charge policies are possible with adequate support from a combination of fiscal and legal measures. A final issue is that debt service will need to be paid in foreign currency and cost recovery is figured on the basis of local currency. Therefore issues of convertibility and foreign exchange risk arise.

### ***Project Implementation***

The role of the project management organization during project implementation will depend greatly on the final institutional affiliation of the incineration plant. For a fully privatized facility, the project organization will monitor project progress and control the contractor's fulfillment of his obligations. For a publicly owned and operated plant, the project organization will not only have to monitor and control the progress of the actual plant implementation, but also establish the plant management organization.

Finally, the decision to implement a solid waste management program involving incineration will have long-term impacts on a municipality's finances. It involves many players and interlocking contractual arrangements which are difficult to modify. A misstep early on could have serious financial consequences. It is imperative that a decision to incinerate be preceded by a period of study and analysis involving technical and institutional feasibility, financial feasibility, and an assessment of public attitudes.