

Editor's Note: The following paper is a written synopsis of comments presented at the Panel on Risk Assessment

RESOURCE RECOVERY FACILITIES— ATMOSPHERIC EMISSIONS: DISPERSION AND DEPOSITION MODELING

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ABSTRACT

To satisfy State and Federal requirements prior to obtaining a license to construct and operate a resource recovery facility, an ambient air quality and risk assessment must be performed. The present state of the technology for evaluating ambient impact of air-borne emissions is subject to significant variations. This paper reviews the present methods and parameters used to evaluate ambient impact and demonstrates the range in predictions. Although no "right" approach has been established, the relative advantages and disadvantages are discussed.

INTRODUCTION

Many states are now requiring that an evaluation of the health risk impacts be performed prior to permitting a resource recovery facility. The concern is whether the air-borne emissions may pose a health risk to the nearby population. Evaluation of potential health risk impacts is a two step process. The first step involves evaluations of the expected ambient air quality and particle deposition due to toxic emissions from the resource recovery facility. The second step is an assessment of the health risk to individuals as a result of intake of the toxic pollutants caused by exposure to the (predicted) ambient levels. This paper discusses

the methods and procedures for predicting the potential ambient air quality and deposition impacts due to proposed resource recovery facilities. The methods for calculating the risk assessment are discussed in a separate paper.

Concern about air toxics, particularly air toxics emitted from resource recovery facilities, was not initially an issue. Early resource recovery plants were permitted based upon an assessment of criteria pollutant emissions and impact. The issues raised by dioxin and hydrochloric acid emissions resulted in more detailed review of proposed resource recovery plants. Since chloride compounds may be in the material combusted and chloride is considered a precursor of dioxin and furan compounds, concern over potential toxic and carcinogenic pollutants increased. Permitting a resource recovery facility now involves assessing the impact of a number of compounds.

Calculating the expected impact of a resource recovery facility involves gaseous and particulate emissions. The use of fabric filters to control particulate emissions results in primarily fine particles being emitted. These fine particles can also carry absorbed gases. Therefore the ambient impact of both need to be assessed to satisfy permitting requirements.

National and state ambient air quality standards have been established for air pollutants referred to as criteria pollutants; particulate matter, sulfur dioxide,

nitrogen oxides, lead, hydrocarbons (total, as precursors to ozone) and carbon monoxide. Additional pollutants regulated by the federal Environmental Protection Agency (EPA) and states as National Emissions Standards for Hazardous Air Pollutants (NESHAP) include arsenic, asbestos, benzene, vinyl chloride, radionuclides, beryllium, mercury, sulfuric acid mist and total reduced sulfur. Additionally, coke oven emissions, which include polycyclic aromatic hydrocarbons (PAH) have been listed by EPA as pollutants to be regulated. Evaluations are required for the ambient air quality impacts of criteria pollutants and NESHAP's from significant sources (proposed emissions greater than 100 or 250 tons/year), in order to obtain air quality permits.

Beyond these categories are toxic pollutants that many states are beginning to regulate as air toxics and already regulate as water pollutants. These pollutants include such compounds as metals, dioxins, furans, and polychlorinated biphenals (PCBs).

To assure compliance for established criteria and NESHAP pollutants, the EPA and all states have established new source review (NSR) and prevention of significant deterioration (PSD) regulations. The state regulations are modeled after the EPA regulations. The rules require the air quality impact assessment of any resource recovery facility that emits more than 250 tons per year of any regulated pollutant.

States such as California, Connecticut, Massachusetts, New Jersey, and New York, for example, have regulations that require an environmental impact assessment as well as the traditional new source review associated with evaluating the air impacts of large single source facilities. The specific approach and review varies with each state, however. New York and Connecticut, for instance, have regulations which involve a screening analysis to see if toxic pollutants have the potential to exceed acceptable ambient levels (AALs). California and New Jersey require a risk assessment of specified pollutants and any other contaminants that the state further requires. Almost all states with a regulation for the assessment of air impacts of a proposed facility allow a two-tier assessment. That is, a screening analysis is initially made using conservative (greater impact) assumptions. If the results of such an assessment demonstrate compliance with ambient air quality standards (AAQS), AALs and risk factors, then the proposed facility is considered to have demonstrated the potential for compliance. If however, the screening analyses shows the potential for adverse impacts, then more detailed analysis can be performed to demonstrate the potential for compliance. The more detailed analysis involves using less conservative pa-

rameters in the assessment that can be demonstrated applicable to the site or facility specific analysis.

The more detailed analysis is made difficult by the state of development of values for the parameters that are critical in the analysis. Since this type of air quality impact and risk assessment is relatively new, there are few proven critical parameter values that have been calibrated with actual operating data. As a result, state regulatory agencies prefer to take a conservative posture. California and New York for instance prefer to have a particle settling velocity of 1 centimeter per second (cm/sec) used in the deposition modeling analysis. While this value is generally recognized as conservative, the regulatory agencies prefer to err in providing additional protection of public health.

The air quality and environmental impact assessment, either in the screening or more detailed mode involves two types of comparison for a demonstration of potential compliance:

(a) Established ambient air quality standards for criteria pollutants and some NESHAPs.

(b) Acceptable ambient levels for toxic air pollutants.

Once a facility has demonstrated the potential for compliance, further demonstration is usually required as a condition of permitting. Emissions testing via grab samples must be performed to demonstrate that the air pollutants emissions, specified on the permit or license, can actually be met by the operating facility. Additional monitoring requirements may also be specified in the permit or license. Connecticut, for instance, is requiring more recent waste-to-energy (WTE) facilities to install continuous emission monitor (CEM) systems on the exhaust stack. Data will then be telemetered to the agency office for periodic processing and review. Ambient monitoring may also be required in some states. Since the dispersion modeling contains inherent uncertainties, some regulatory agencies require ambient monitoring to confirm the predicted impacts. If either the emissions or ambient monitoring shows greater pollutant concentrations than predicted during the permitting process, the permit or license will be modified for less impact.

IMPACT ASSESSMENT

Evaluation of the potential impact of a resource recovery facility involves three phases as follows:

- (a) critical pollution identification
- (b) pollutant emission quantification
- (c) dispersion modeling

TABLE 1 WATER QUALITY CRITERIA FOR HUMAN HEALTH

Compound	Water Consumption Criteria ^(a)
PAH	0.000031 ^(b)
Arsenic	0.000025 ^(b)
Beryllium	0.000039 ^(b)
Nickel	0.0154
Lead	0.05
Dioxin as TCDD	0.0000000018 ^(b)

(a) Adjusted criteria from U.S. EPA, 1986, Superfund Public Health Evaluation Manual, EPA 1540/1-86-060.

(b) The criteria value is zero for all potential carcinogens. The concentration value corresponds to a risk of one in a million.

CRITICAL POLLUTANTS

As discussed above, a number of pollutants need to be evaluated for potential compliance with AAQs and AALs. Not all of these pollutants however are critical in performing the risk assessment. The criteria pollutants are not of sufficient toxicity nor result in an impact that represents a potential health concern. NESHAPs, such as asbestos and radionuclides, are not always associated with emissions from resource recovery facilities. In the risk assessments that have been performed for these facilities, certain pollutants have consistently been of concern in the risk assessment. These pollutants include:

- (a) dioxins
- (b) PCBs
- (c) PAHs
- (d) trace metals
- (e) acid gases

Permitting a resource recovery facility will generally require evaluating the potential emissions and impact of these pollutants.

These pollutants are of concern because of the potential high sensitivity of individuals and resulting adverse effects. The relative sensitivity is demonstrated in Table 1. The EPA water quality criteria are shown for some of these pollutants. These criteria are not standards, but recommended criteria for evaluation of adverse effects on human health. As is evident from Table 1, concern levels have been established at trace concentrations. Even very small emissions from a resource recovery facility can become a major issue in permitting a new plant.

POLLUTANT EMISSIONS

It is evident from the above discussion that the specified rate of a pollutant emission from a resource re-

TABLE 2 SELECTED POLLUTANTS EMISSION RATES FOR RESOURCE RECOVERY FACILITIES

Pollutant	Approximate Controlled Emission Data (grams/sec)
Dioxin (TCDD)	0.000002 - 0.00000004
Hydrogen Chloride	10 - 0.1
PAH (total)	0.001 - 0.00005
Arsenic	0.0001 - 0.00001
Beryllium	0.000001 - 0.00000001
Chromium (Hex)	0.001 - 0.0001
Mercury	0.01 - 0.001
Zinc	0.7 - 0.01
Lead	0.1 - 0.004

covery facility can be critical in assessing the potential risk. Until recently the only control requirement on these facilities was for particulates. As a result, an extensive data base has not been developed on the actual emissions associated with resource recovery facilities. Since the emissions depend upon the characteristics of the waste being combusted, the pollution control equipment and the specific design (including temperature and residence time), emissions will vary from facility to facility. Some examples of the range of pollutants emissions rates is shown in Table 2. It is evident from these general ranges that compound emission rates can vary by one to two orders of magnitude and still be a trace concentration. Measurement of these levels strains the current state of the technology. The dioxin emissions rate of 0.00000008 for instance, represents the detection limit of the source sampling equipment for this facility. The evaluation of the quantity of emissions to be used in dispersion modeling therefore has inherent uncertainties. Since the resource recovery facilities are usually constructed with a single stack, an uncertainty in the emission rate would be directly translated into an uncertainty in the predicted impact.

DISPERSION MODELING

As discussed earlier, the air impact assessment involves the calculation of two types of impacts:

- (a) ambient air quality impacts
- (b) dry deposition of particles

Both approaches involve the use of EPA approved guideline dispersion models ("Guideline on Air Quality Models," U.S. EPA, 1986, EPA 450/2/78-027R). The most commonly used model is the ISC (Industrial Source Complex) model. This model has versions for

annual averages, ISCLT, and shorter term average impacts, ISCST. This model has flexibility in applications in that it can treat multiple sources, irregular terrain, various averaging times and dry depositions. While the ISC model is an EPA approved model it is not without critics who have raised concern about the predicted impacts that result from using this model. Some specific concerns include whether the model conserves mass in all situations and whether the calculation of deposition is appropriate to specific situations. In applying the ISC model to a resource recovery facility, there are basic data and parameter value selections that will affect the predicted impact and thereby the risk assessment. These data and values include:

- (a) emissions rates
- (b) meteorology data
- (c) reflection terms
- (d) particle setting velocity

The emission rates have already been discussed. Resource recovery facilities are generally constructed with a single stack. Therefore any change in the emissions will result in a direct change in the predicted impact. For instance, if the emission rate were determined to be an order of magnitude less, the predicted impact would be decreased by an order of magnitude.

The choice of meteorology data can affect the resulting predicted impacts. Meteorology data input into the model includes wind speed, wind direction and stability conditions. The plume from the facility will be treated differently for variations in each of these values. Scientifically, it is desirable to use on-site meteorology data. However, this is rarely available. Generally, the site regulatory agency will specify the meteorology data set to be used, usually from a nearby airport. This is not always straight forward. A recent application for a WTE plant to be located in Connecticut very near to Rhode Island used Hartford airport meteorology data. If, however, meteorology data from Providence, Rhode Island, which is closer to the proposed site, had been used, a greater impact would be predicted. Table 3 shows the difference for the two data sources as percent of wind from the directions that would have resulted in impacts in Rhode Island. The Rhode Island data sets would have resulted in a greater annual exposure.

Even the use of regulatory specified data sets can result in different predicted impacts. In a recent analysis performed by Jordan scientists the effect of using different years of record was evaluated. A five year data set had been used to predict ambient air quality impacts. One year was found to result in the maximum impacts. This same year was then used to predict dry deposition impacts. Rechecking the depositional im-

TABLE 3 COMPARISON OF ANNUAL WIND DIRECTION FREQUENCY (In Percent)

Direction	Bradley Field Windsor Locks, CT	T.F. Green Field Providence, RI
	1970	1985
SSW	4.2	8.7
SW	2.9	6.3
WSW	3.6	8.1
TOTAL	10.7	23.1

NOTE: Wind direction is the direction from which the wind is blowing. Winds from the south-southwest (SSW), southwest (SW), and west-southwest (WSW) will transport pollutant emissions from the proposed facility towards Rhode Island.

fact using the other data years showed a greater impact by a factor of approximately 50%.

REFLECTION TERM

The ISC model requires users to specify, among other terms, whether the pollutants emitted will be 100% reflected from the ground surface or 0% reflected (100% deposited). Intermediate value assumptions are possible. Regulatory agencies generally prefer to have ambient air concentrations determined with 100% reflection and deposition determined with 100% deposition. Depending upon the distance from the source and the characteristics of the particles, the use of different reflection terms can result in approximately a 3 to 10-fold variation in the predicted impact. There have been some studies to suggest that the fine particles (1-10 μm) actually behave more as a gas and may actually be significantly "reflected" from the ground. The implication for the health risk assessment is the potential for overpredicting the exposure. While prediction of ambient air quality impacts with the 100% reflection term has been historically used in such analysis, the prediction of deposition is a relatively recent approach. As such, the appropriate value for the reflection term is undergoing considerable debate. In lieu of more field data to suggest a less conservative approach, regulatory agencies will probably continue to require the use of 100% deposition, at least in the first-tier screening analysis.

DEPOSITION TERM

Another significant parameter value used in the ISC model for deposition is the settling velocity, or rate at which the particles are considered to settle in the atmosphere. States such as California and New York

**TABLE 4 CUMULATIVE EFFECT OF CRITICAL
PARAMETER SELECTION**

<u>Parameters</u>	<u>Potential Effect on Predicted Impact</u>
Emission Rates	± 10 - 100 Times
Meteorology	± 0.50 Times
Reflection	± 3 - 10 Times
Deposition Rate	± 3 - 20 Times

prefer to have a value of 1.0 cm/sec used in the analysis. There is evidence to suggest that this value may be conservative for resource recovery facilities. Values of 0.3 to 0.05 have been suggested as being more appropriate for the fine particles expected from resource recovery facilities. Such a variation in the value used for this term could result in a 3 to 20-fold variation in the predicted deposition impact.

The cumulative effect of the values that might be used for these critical parameters is shown in Table 4. Each of the terms discussed above affects the resulting predicted impact independently. Therefore, the net effect could be additive, resulting in one to four orders of magnitude difference in the predicted impact due to use of various values for just these parameters. These are various other parameter values in ISC that are user

specified, as well as the question of the representatives of the ISC deposition algorithm for the resource recovery application. In any event, the potential exists for a significant variation in predicted exposure. The more assertive state regulatory agencies will specify the preferred values, at least for use in the screening analysis. The applicant must then be prepared to document the appropriateness of other less conservative values for use in the more detailed impact analysis.

SUMMARY

In order to determine the potential health risk associated with a proposed resource recovery facility, predictions of ambient impacts are performed with dispersion and deposition modeling. This modeling involves use of estimates and assumptions that can affect the predicted impact by at least one to four orders of magnitude. The use of the more conservative values is generally preferred by state agencies at least for the first-tier screening impact analysis. An applicant for a new resource recovery facility must then be prepared to document the use of less conservative parameter values in the second-tier more detailed impact analysis or significant over-prediction of the exposure to be used in the risk assessment will result.