North Carolina Division of Air Quality (DAQ) Progress Report on the Boiler-Combustion Source Exemption from NC Air Toxics Program Study; Prepared for March 8, 2006 NC Air Quality Committee Meeting

Boilers and other combustion sources[1] are exempt from the North Carolina Air Toxics Rules until after the Maximum Achievable Control Technology (MACT) combustion rules are developed. In 1997 the Environmental Management Commission decided not to permanently exempt boilers, but rather to delay the review. This allows the Commission to consider the federal MACT requirements before finalizing its decision on the state's combustion source exemption. Given the Combustion MACT rules were promulgated in late 2004, it is time for the:

1. DAQ to assess the MACT combustion rules to determine whether additional measures are necessary with respect to toxic pollutants, and
2. Commission to review DAQ's assessment and to proceed through normal rulemaking procedures, if necessary, to implement additional measures. The Commission shall decide whether to keep or remove the combustion source exemption. If the commission decides to remove the exemption, it shall initiate rulemaking procedures to remove the exemption.[2]

As part of the Combustion MACT analysis, DAQ performed an assessment of the permitted combustion sources with the current, pre-MACT emission levels. The EPA Human Exposure Model (HEM) Screen was applied. HEM-Screen contains a dispersion model, census tract data, and toxicity potency factors for hazardous air pollutants to estimate inhalation exposure and risk. The model can produce cancer risk and health hazard estimates for multiple facilities statewide. As input into HEM-Screen, DAQ compiled a database of the State's nearly 2,000 permitted combustion sources. The database includes the latest information on toxic pollutant emission inventory, stack characteristics, and facility location coordinates. To assess the benefit, DAQ planned to perform post-MACT modeling by estimating emission reductions for Combustion MACT-affected sources.

1.0 COMBUSTION SOURCE MACT RULES ASSESSMENT

Rule 15A NCAC 2Q .0701 requires DAQ to "… assess the boiler-combustion MACT standards to determine whether additional measures are necessary with respect to toxic air pollutant emissions from combustion sources." To evaluate the MACTs, DAQ assembled a list of all Title V facilities with combustion sources located in North Carolina. This list was divided into categories aligned with the combustion source types as defined by the three MACT rules, including the:

- Industrial/Commercial/Institutional Boilers and Process Heaters MACT Rule (herein referred to as the Industrial Boiler MACT),
- Stationary Combustion Turbine MACT Rule (herein the Turbine MACT), and
- Reciprocating Internal Combustion Engines (RICE) MACT Rule (herein the RICE MACT).

There are over 300 sources in the state subject to the Combustion MACTs in terms of initial notification, reporting, recordkeeping, or emission standards. However, based on review of the MACT rules and other related information, DAQ has found no sources subject to emission

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[1] . "*Combustion sources* means boilers, space heaters, process heaters, internal combustion engines, and combustion turbines, which burn only unadulterated wood or unadulterated fossil fuel." 15A NCAC 2Q .0703(6).

[2] 15A NCAC 2Q .0701(b) and 15A NCAC 2Q .0702(a)(18).

reduction requirements resulting from the Combustion MACT rules. In other words, the pre-MACT emission levels will be the same as the post-MACT emissions for existing combustion sources. This is not to imply that Combustion MACT-affected sources have no other MACT requirements, because many do have requirements in terms of notification, recordkeeping, reporting, fuel analysis, and/or emission testing. The following explains why there are no emission reduction requirements from the Combustion MACTs.

1.1 Industrial Boiler MACT

The Industrial Boiler MACT affects 125 boilers in North Carolina and contains emission standards for existing solid fuel (coal and wood) fired units. Emissions from NC boilers were assessed for comparison to the standards by compiling emission factor data from a variety of sources, including:

- DAQ's electronic database,
- EPA's AP-42 files, and
- Industrial Boiler MACT data.

These data indicate emission levels in compliance with the standards, and in most cases with a safety margin of 2 or more. In addition, DAQ permitting staff have not yet received any permit applications from boiler owners to install any new emission controls in response to the Industrial Boiler MACT. Independent of our review, DAQ staff contacted boiler owner staff and learned they have performed their own evaluations and likewise found indications their current emissions comply with the Industrial Boiler MACT standards. The boiler owner representatives include:
- Furniture Industry Trade Group representing several furniture plants in NC,
- Paper Company "A" corporate engineer overseeing MACT compliance in NC and other states,
- Paper Company "B" environmental engineering staff with one of NC largest boilers,
- Consultant for major local university with two of NC largest boilers.

1.2 Turbine MACT Rule

The Turbine MACT sets emission standards for formaldehyde for only new stationary combustion turbines burning liquid and gaseous fuel. Any existing units are not subject to any emission standards. In North Carolina there are roughly 35 existing combustion turbines units installed at eight major sources potentially affected by the MACT. Of these, none are subject to any emission standards, and therefore none are required to reduce emissions nor install new emission controls since they are existing units. EPA Turbine MACT staff confirmed these conclusions. In addition, DAQ permitting staff have not received any permit applications from turbine owners to install new emission controls in response to the Turbine MACT.

1.3 Reciprocating Internal Combustion Engines (RICE) MACT Rule

This MACT, commonly known as the RICE MACT, sets emission standards for existing units classified as 4-stroke rich burn gas fired engines larger than 500 brake horsepower at major sources. In North Carolina there are 105 units installed at roughly 25 major sources that are potentially affected by the RICE MACT. However, none of these meet all criteria, and therefore none are subject to RICE MACT emission standards. EPA RICE MACT staff confirmed these conclusions. In addition, DAQ permitting staff have not received any permit applications from RICE owners to install new emission controls in response to the RICE MACT.

2.0 DESCRIPTION OF HEM-SCREEN MODELING AND RESULTS

The HEM-Screen is a combined air dispersion, and exposure and risk model. The air dispersion portion of the model estimates the concentrations of a pollutant surrounding a source based on source-specific pollutant emission rates and release parameters. The exposure and risk portion of the model combines the estimated pollutant concentrations with the known population surrounding the source to determine possible human exposure and risk. DAQ ran HEM-Screen with source emission and risk information to obtain both pollutant concentration distributions and human exposure and risk results.

2.1 Estimating Pollutant Concentrations

The HEM-Screen model is designed to operate with a minimum of input information. The HEM-Screen uses a simplified Gaussian dispersion model based on the ISCLT2 (EPA Report No. EPA-450/4-88-002a, 1987) to estimate pollutant concentrations. To reduce information required by the user and improve computational efficiency, certain assumptions are made, including:

1. Weather data from the geographically closest meteorological station are representative of the weather data at the source,
2. All emissions from a source are released from one location with a specific set of latitude and longitude coordinates representing the center of the source (i.e., multiple release points scattered across a source are modeled as if all release points are located at the source's center),
3. Meteorological stability classes are selected based on whether the source's location is classified as an "urban" or "rural" setting, and
4. Terrain surrounding the source is flat (i.e., no hills or valleys).

The HEM-Screen input information for the air dispersion and concentration estimation portion are:

1. Source location in latitude and longitude coordinates (degrees, minutes, and seconds)
2. Pollutants' emission rate (kilograms per year), and
3. Key release parameters, including:
   i. Stack height (meters),
   ii. Inner stack diameter (meters),
   iii. Gas exit velocity (meters per second), and
   iv. Gas release temperature (Kelvin).

Based on the emission release input data, HEM-Screen generates a polar receptor grid of concentrations centered on the location provided for the source. The source location is defined as a set of latitude and longitude coordinates representing the center of the source. Depending on whether there were one or several combustion units, the source represented a single or a group of emission release points at a facility.

The polar receptor grid is based on ten radial distances from the source. As shown in Figure 1, these radial distances define ten concentric circles around the source. The HEM-Screen allows the user to select from 8 established sets of radial distances. The directional component of the polar receptor grid is comprised of the 16 standard meteorological wind directions from the source.

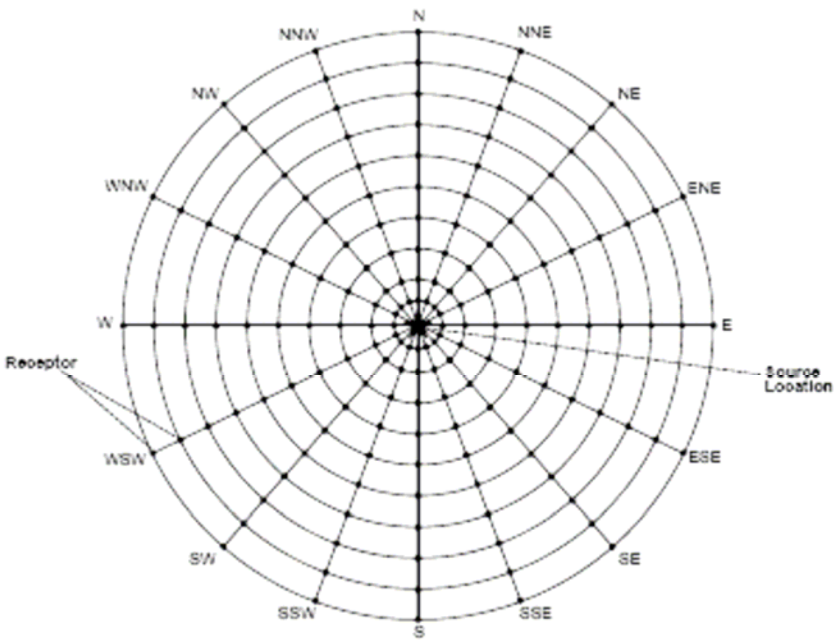

Figure 1. Example HEM-Screen Polar Grid

The wind directions are set by HEM-Screen and are the lines beginning at the radial distance closest to the source and radiate away ending at the furthermost radial distance. Each intersection point where a distance ring and a wind direction line meet is called a receptor. The HEM-Screen estimated the annual average, ground-level pollutant concentration at each of these 160 receptors defined by the 10 distances and 16 directions.

2.2 Estimating Population Exposure and Risk

The 2000 Census data in HEM-Screen was used to estimate the population surrounding each source. The Census data provide:
1. Latitude and longitude coordinates of each Census block centroid, and
2. Number of people counted in that Census block.
This was done in combination with the pollutant concentration distribution or "grid" to provide a concentration grid with 160 receptors.

Since DAQ was interested in estimating maximum individual cancer risk or annual cancer incidence result, a unit risk estimate (URE) was entered. This is the cancer risk to an individual if they inhale 1 ug/ m^3 of pollutant for a 70-year lifetime. Since DAQ was also interested in estimating the hazard index (HI), which is a ratio of the inhalation reference concentration (RfC) and maximum concentration, we entered the inverse of the RfC and converted to units of ug/m^3.

To estimate exposure, the model used the four receptors closest to the centroid of each Census block to estimate the concentration at the Census block. The HEM-Screen then multiplied the interpolated concentration by the number of people in the Census block to determine total exposure for that Census block. This determination is based on the assumption that all of the people in the Census block reside at the centroid of the Census block and never leave that location for their lifetime. The total exposure for a source is then estimated by summing all of the total exposure values for the individual Census blocks in the modeled area. This is the total exposure used to generate the annual incidence for a source. In the process of interpolating concentrations at each Census block, HEM-Screen selects the highest concentration estimated for any Census block. This is the maximum concentration that determines the maximum cancer individual risk or the chronic, non-cancer health quotient (HQ) for one pollutant from that one source. This concentration is not necessarily the maximum modeled concentration. If no Census block centroids are near the source, the concentrations on the first or second radial distance may exceed the concentration estimated for the maximum individual risk. The intention is to estimate the highest concentration to which a person is likely to be exposed. It is possible that the first radial distance falls within the source property, where no one resides or is exposed.

2.3 Applicability of HEM-Screen

The HEM-Screen incorporates several simplifications and assumptions, yet the model provides relatively accurate screening-level representations of maximum risk and population exposures, assuming sound judgement is used in selecting the input data. It is important to realize that HEM-Screen yields risk estimates based solely on exposures by the inhalation route and only for pollutants dispersed in gaseous form. ***It does not model particulate matter, unless the particulate is so small that the particles move and behave like gases***.

The HEM-Screen defines “exposure” as a pollutant concentration multiplied by the number of people subject to the pollutant concentration (concentration x people). The exposed population in a given dispersion area is assumed to be all those who reside in that area, based on U.S. Census 2000 data. In other words, important exposure variables (e.g., duration of contact, human mobility patterns, and residential occupancy period) are not HEM-Screen variables that can be altered in the risk calculation. Hence, the exposure factors used in the model are only simple surrogates for actual exposures, and consequently, the most effective use of HEM-Screen is as a screening model.

2.3.1 Strengths

The HEM-Screen provided the following benefits:

1. Required only a few data inputs generally easy to obtain;
2. Incorporated meteorological data from many sites statewide without the need for data collection or further data processing;
3. Has North Carolina Year 2000Census population data at the block level;
4. Generated estimated pollutant concentration values that compare favorably with values from the standard air dispersion model DAQ routinely uses for toxics modeling for point sources;
5. Adapted to model multiple pollutants as a single surrogate value;
6. Added cumulative exposure and risk from the proximity of multiple sources;
7. Relatively quick and easy to run; and
8. Provided organized and useful concentration, exposure, and risk outputs.

2.3.2 Limitations

Although HEM-Screen is a comprehensive tool, there are limitations that make the model most suitable for screening-level assessments. The following items can limit the use of HEM-Screen in this application:

1. Does not model hilly or mountainous terrain in western North Carolina - assumes flat terrain;
2. Does not estimate short-term (i.e., acute) exposures - always estimates an annual average pollutant concentration; and
3. Does not determine environmental reactions or transformation products of pollutants.

2.4 Presentation of HEM-Screen Preliminary Results

HEM-Screen models were run for all identified combustion sources using the latest available emissions inventory data. Individual combustion sources were grouped by air quality region. For each combustion source, emissions inventory data were normalized to allow calculation of a single overall cancer or non-cancer risk value per source rather than risk values for each pollutant per source. Modeling was run for nearly 2000 combustion sources

2.4.1 HEM-Screen Model Outputs

The HEM-Screen model produces cancer risk values expressed as lifetime cancer incidences per unit population (i.e. one in a million). Noncancer risk is expressed in terms of hazard index (HI). Guidelines for interpreting these risk values are:

Cancer risk – Less than 1 in one million = low priority risk
Greater than 100 in one million = high priority risk

Hazard index -Less than 1 = low priority risk
Greater than 10 = high priority risk

2.4.2 Preliminary HEM-Screen Cancer Risk Results

Of the nearly 2000 combustion sources modeled, about 70 showed maximum cancer risk greater than 1 in one million. Highest risk observed was about 32 in one million. About 75% of the 70 combustion sources were wood- or wood waste-fired units, with the remaining 25% firing coal, oil, or natural gas.

The primary pollutants driving the cancer risk are shown below.

Wood fired units – Hexachlorodibenzo-p-dioxin (~84% of risk)
Chromium compounds (~10% of risk)
Arsenic (~4% of risk)
Benzene (~1% of risk)

Coal fired units - Arsenic (~96% of risk)
Cadmium (~3% of risk)

2.4.3 Preliminary HEM-Screen Noncancer Risk Results

About 20 of the nearly 2000 combustion sources modeled showed a maximum hazard index greater than 1. The highest hazard index observed was about 4.4. About 70% of these combustion sources were wood- or wood waste-fired units, with the remaining 30% firing coal, oil, or natural gas.

The primary pollutants driving the noncancer risk are shown below.

Wood fired units – Acrolein (~85% of risk)
Manganese (~14% of risk)
Arsenic (~4% of risk)
Benzene (~1% of risk)

Coal fired units - Acrolein (~73% of risk)
Phosphorous (~16% of risk)
Arsenic (~4% of risk)
Chromium compounds (~4% of risk)

2.4.4 Remaining Work

To complete the study of toxic emissions from combustion sources, the following work will be done:

- Additional modeling of the high risk units identified by the initial screening, using an enhanced model (HEM-3).
- Further database operations and statistical analysis of the data based on the following factors
    - Fuel Type
    - Specific pollutants
    - Combustion source heat input rate
    - Control devices
    - Total population exposed at levels above risk thresholds
    - Regional and statewide risk totals