Reviewer: **Brian Leaderer - Yale University**

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Reviewer Comments:

Development of Microenvironmental Factors for the HAPEM4 in Support of the National Air Toxics Assessment (NATA)

The following are my responses to the seven questions posed in the review of the above document:

1. **Is HAPEM4's application proposed for the initial NSA consistent with the recommended uses of this model? Given the national goals of the initial NSA, is this model the appropriate model to use?**

The HAPEM4 model is used here in an attempt to predict the inhalation exposure for the U.S population to 33 hazardous air pollutants. The model focuses on only one route of exposure (air) from only outdoor sources. It accesses the contribution of outdoor sources to exposures in a variety of microenvironments. The major strength of the model is its ability to process large amounts of data, thus permitting exposure estimates on a census tract scale. The application of the model may be very misleading.

The report and accompanying documents acknowledge that it is necessary to determine for each hazardous air pollutant (HAP): their sources (air, food, soil and water), pathways, and routes of exposure, if total exposures are to be assessed and targeted cost effective mitigation measures developed. Having said that, the report goes on to predict only inhalation exposures to outdoor generated HAPs. I understand the regulatory charge to EPA is to consider only outdoor sources. The model approach used to estimate exposures and develop regulatory activities, however, may be grossly inaccurate in accessing total exposure, and result in ineffective control policies, policies which may be expensive, but not provide any improvement in public health. The reason given for not using a more comprehensive total exposure model, was that the available information does not support such an effort. My impression is that a total exposure model would be no less accurate than the model used to estimate inhalation to outdoor generated HAPs. At the very least, the report should contain a section that discusses and presents an estimate of the % contribution by outdoor sources of HAPs, to total exposure, so the reader can determine how important the outdoor sources are to total exposure. This would put the modeling effort into perspective and indicate the most important sources and pathways.

2. **Is the proper scientific approach to developing a ME concentration employed by the HAPEM4 model? If not, what other approach would you recommend.**

Microenvironmental concentrations are estimated for 37 microenvironments and 33 HAPs, using a series of assumptions related to outdoor emission sources (mobile, point and area), dispersion modeling (ASPEN dispersion model) and indoor/outdoor concentration ratios. There was not enough information presented in the report to provide a critical

evaluation of the ASPEN model. I do, however, have some problems with how the HAPEM4 estimates concentrations within microenvironments:

a) the contribution to indoor levels from indoor sources in various microenvironments (ADD), probably the most important source of inhalation exposure, were not assessed or discussed.

b) the PEN factors were estimated from the literature where indoor/outdoor factors were determined from measurements taken outside and inside specific microenvironments for specific pollutants. Appendix B and C present a summary of the results. The criteria for the inclusion or exclusion of published papers in estimating I/O ratios, was not clear or very critical. It is extremely difficult to insure that there are no indoor sources associated with any of the I/O measurements reported in the literature. I/O ratios will vary greatly by season, region of the country, type of construction, presence of an air condition and several other factors. To merely average reported values can be very misleading. My familiarity with the literature would lead me to believe that virtually all the I/Os shown in Appendix C are very high. I would much prefer a more critical set of criteria for inclusion of studies, and a more critical assessment of I/Os. It is entirely possible that the available data does not support assigning an I/O ratio for many pollutants, and that several should not be modeled. The need to group microenvironments and HAPs is an indication of how little data is available.

c) lack of I/O information for many pollutants resulted in use of the "lifetime grouping method" to assign I/O values to those pollutants without published I/O factors. This estimate presumably accounts for losses by the building envelope, chemical reactions and removal by interior surfaces. This method was not critically evaluated and is another potential source of substantial uncertainty that should be addressed.

d) a tremendous number of assumptions are made in estimating equation 4. At no point is the magnitude of the uncertainty estimated in the calculations of ME or its' components (ADD, PROX, PEN or AMB). It is not enough to briefly discuss some of the possible sources of uncertainty and, some bounds must be placed on the estimates.

e) given all the assumptions and uncertainty associated with the model, there should be some attempt to validate it or at least some components of it. Without some validation, its use for assessing exposures to inhaled pollutants from outdoor sources is very problematic.

3. Has a complete and appropriate scientific literature review been performed in the development of the HAPEM4's ME factors?

It is really hard to judge. It appears the authors made a good attempt to identify and include the relevant literature. They apparently identified over 5,400 articles, but reviewed and used only about 140. The criteria for including or excluding any particular study is not at all clear. I can not tell from Appendix A, which journals the articles where published in, or if data published in the proceedings of the several International Indoor Air Conferences were used. These conference proceedings often do not show up in library searches. My major concern is whether there was a critical and balanced review of the articles.

4. Are there significant scientific improvements in the exposure assessment field that should be incorporated in this model for future national-scale assessments?

Probably not. I think there is an obligation to include estimates of exposure from other media, pathways and routes. Errors associated with these estimates are probably not much more uncertain than those presented in this report for contaminant inhalation associated with outdoor sources. This would at least put the outdoor source contribution into some reasonable context. I am of the opinion that the available data does not support such an assessment at this time.

5. **Can the uncertainties associated with the use of the HAPEM4 model be defined? If so, how can a quantitative assessment of this uncertainty be defined and implemented?**

Every component of the model has a considerable amount of uncertainty associated with it. Some factors associated with the uncertainty are mentioned in the report, but no effort is made to estimate that uncertainty. One area that may be looked at, is the I/O ratios obtained from the literature. It should be possible to put error bars around the numbers used. At the least, the report needs to highlight the likely high level of uncertainty associated with model results and provide a strong caution on use of model predictions.

6. **Does the HAPEM4 modeling system deal with uncertainty in an adequate and transparent way? Does HAPEM4 adequately integrate the uncertainty, qualitative or quantitative, into the presentation of the analyses such that the eventual consumer of the NATA will understand the nature and magnitude of uncertainties associated with the exposure estimates? If not, how can we improve the treatment of uncertainty in this modeling system**?

No. Uncertainty associated with use of the HAPEM4 model is not adequately characterized or fairly represented in this report. Use of the model to assess exposures is likely to result in substantial errors, and in the development and implementation of control policies that will not improve public health. As already noted throughout this review, the high level of uncertainty associated with estimates generated through this model, is not adequately highlighted. There is a substantial probability that the model results will be misinterpreted and misused. It should also be emphasized, that neither the model nor any of its components, have been validated for use in estimating exposures to HAPs.

7. Can a more quantitative estimate of uncertainty be attempted? If so, can you make specific suggestions about quantifying individual as well as composite uncertainties associated with the HAPEM4 model.

While I can not make any specific suggestions, other than establishing error bars on the I/O estimates, a serious effort is needed to better characterize and present the uncertainty associated with the model.