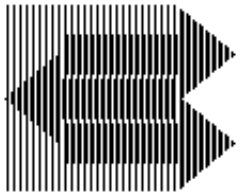

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Energy Laboratory

Massachusetts Institute of Technology

SYMPOSIUM SUMMARY

EPA's Urban Air Toxics Strategy

1999 Urban Air Toxics Summer Symposium

October 1999

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EPA's Urban Air Toxics Strategy

1999 Urban Air Toxics Summer Symposium

Symposium Chair: Dr. Robert Slott, MIT
Program Committee:
Debra Kaden, HEI
Praveen Amar, NESCAUM
Larry Cupitt, EPA ORD

Sponsored by the MIT Energy Laboratory

Held at

Endicott House
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Proceedings prepared by Renee J. Robins, MIT

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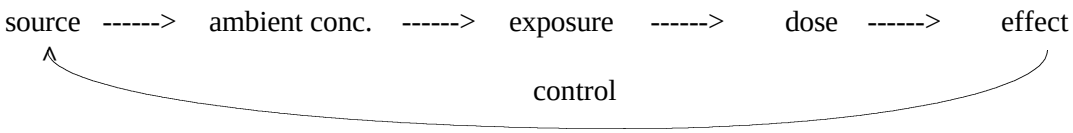
EXECUTIVE SUMMARY

The Summer Air Symposium is a continuation of conferences established in 1993 for the purpose of informing decision makers on scientific aspects of important air pollution issues. Participation is limited to invited members of the scientific, regulatory, industrial, and public interest communities. The small size of the group promotes discussions that have led to important progress on ideas for improvements in air pollution control. The conference is co-sponsored by a variety of organizations (see Appendix I).

The objective of the 1999 Symposium was to discuss scientific aspects of EPA's Urban Air Toxics Strategy, including the influence of science on policy and the influence of policy on scientific research. Specific questions to be addressed include:

- What is known?
- What are the uncertainties and their magnitude?
- What research should be done?

The EPA Urban Air Toxics Strategy is a new type of undertaking because it's a *strategy*, not a rule. It sets priorities and a schedule for ongoing action. The Clean Air Act Amendments of 1990 (CAAA) identify 189 pollutants as air toxics. The CAAA establish a two-step approach for regulating these pollutants: (1) standard setting, which is designed to get broad reductions across the board, along with incidental reductions from mobile source programs, and (2) determination of whether additional reductions are needed to protect health and the environment. The Urban Air Toxics Strategy, residual risk standards, and mobile source study and standards come under the second step. The biggest challenge is to regulate while we're still learning: source inventories are evolving and our understanding of atmospheric transformation and cumulative effects is still incomplete. The paradigm is:



Sources present a complex challenge. There are multiple pollutants, multiple sources, and we only have primitive emission characterization. Many ambient pollutants result from transformation in the atmosphere. Monitoring has provided some ambient data—showing some downward trends—but by no means enough. We need a national system, but need to be careful not to overbuild, for resources might be better used elsewhere. There are a lot of existing data that could be analyzed. Data challenges include a lack of prescribed methods and a need to better understand variability. States need to participate in decisions concerning when and how to act.

Exposure is the connection between ambient concentrations and health effects. For toxics, there is a special need to understand indoor vs. outdoor sources and exposures. Indoor exposures are poorly understood. We need to develop source apportionment tools, and this is critical to developing cost-effective control strategies. The Cumulative Exposure Project is a major effort to address all sources, and it has come reasonably close to monitored levels. It is being brought into the Urban Air Toxics Strategy and updated (NATA). The challenges are dealing with a 1990 inventory, improving the quality of modeling, and public/risk communication. MATES II is an example of a very community-oriented attempt to do some of these same things.

Diesel and mercury are in some sense the easy cases. We understand the sources, have health data, and there is a history and technology of controlling emissions. With respect to diesel, the debate is whether its emissions constitute an air toxic or not, and how large the risk is (which can be addressed with quantitative risk assessment tools). There has been less debate today concerning what to do about it. Is it regulated as PM? As an air toxic? Resolving these issues is important for determining diesel control strategies. Mercury is a very public issue because of fish advisories and TRI data. We know the primary anthropogenic sources, and control is possible, although at a cost ("catching a few fish in a big lake").

Health effects are a key element and a major challenge in developing an air toxics regulatory strategy. There is a "miserably inadequate data set for quantitative risk assessment." Only 14 of 33 priority HAPs have potency values, and there are quantification challenges, as well as questions about mechanisms at high and low doses. Unanswered is whether we are aiming for an "acceptable level of risk" (e.g. 1 excess cancer in a million) or an "acceptable level of control" (e.g. MACT).

Finally, there are many research needs to support an overall strategy. Priorities include source characterization and inventory building, atmospheric transformation, improved monitoring techniques and standardization, exposure assessment for key indoor/outdoor toxics, and health science including biomarkers for exposure and dose-response information.

1.0 INTRODUCTION: BOB SLOTT, MIT ENERGY LABORATORY

The Summer Air Symposium is a continuation of conferences established in 1993 for the purpose of informing decision makers on scientific aspects of important air pollution issues. Participation is limited to invited members of the scientific, regulatory, industrial, and public interest communities. The small size of the group promotes discussions that have led to important progress on ideas for improvements in air pollution control. The conference is co-sponsored by a variety of organizations (see Appendix I).

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- What are the uncertainties and their magnitude?
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1.1 Background to the Strategy: Summary of the 6/18/99 Report to Congress

Laura McKelvey, EPA

Air Toxics Program

There are four components:

1. Standard setting activities
2. Risk initiatives (including national, regional, and community-based)
3. Assessments (National Air Toxics Assessment)
4. Education and outreach

EPA's current direction is moving toward more risk activities, including cumulative risk, multi-pathway risk assessments, and multi-pollutant assessments. They are also looking at sources of disproportionate risk, including sensitive populations, geographic hot spots, and environmental justice concerns.

Urban Air Toxics Strategy

The Urban Air Toxics Strategy is one element of the overall strategy. It has the same four components but is focused on urban areas, where there are concentrations of people and sources, sensitive populations, and larger percentages of minority and low-income populations. The Federal Register notice lays out three risk reduction goals:

1. Ensure a 75% reduction in cancer incidence from hazardous air pollutants (HAPs) (stationary and area source) in urban areas nationwide.
2. Substantially decrease non-cancer health risk (area sources) in urban areas nationwide.
3. Target and address disproportionate risk in urban areas (all sources)

Standards: The CAAA requires EPA to identify at least 30 HAPs from area sources with the biggest health risk from area sources. They identified 33 (30 of which had the greatest contribution from area sources). 90% of the emissions from area sources must be subject to regulation. 13 area sources were added for regulation; EPA will add additional sources by 2003.

Assessments and Risk Initiatives: The first set of assessments (ASPEN screening model) is due to be completed in the spring of 2000, and assessments are to be updated every three years with new inventories. The analysis progresses from concentrations to exposure to risk. Models are being

improved to include multi-pathway risk, etc. EPA is looking at local risk. There will be pilot projects in different cities to establish protocols.

Education and Outreach: EPA needs strong stakeholder involvement in order to accomplish these goals, and is working with STAPPA/ALAPCA, environmental groups, and industry.

Mobile Source Emissions

Section 202(l) requires EPA to study toxics from mobile sources. The first study was completed in 1993. An updated version is currently under peer review.

Next Steps

EPA's upcoming focus is on educating people, conducting NATA assessments and building the inventory, prioritizing which standards to write first, targeting pilot projects, and determining the role and responsibility of local governments.

Discussion

Audience members asked if EPA is looking at whether the 188 compounds on the list are the appropriate ones, questioned the effect EPA's definition of "urban area" has on implementing the strategy, and asked about quantitative health information and whether bioaccumulative toxics are included. Ms. McKelvey replied that the CAA stipulates the 188 compounds, so EPA hasn't really looked at the issue of whether they are the "right" ones. They do have the authority to add to the list or remove compounds from the list, and so far have delisted one. As for the urban area definition, she said that the inventory information on which the analysis was based is county-level Urban 1 and Urban 2 definition. (For analytical purposes, both Urban 1 and Urban 2 are used.) They did look at the impact on the list of pollutants if they had focused on both Urban 1 and 2 or only on Urban 1. For standard setting purposes, they aren't limited to the analytical definition. EPA is concerned about urban sprawl and development, and doesn't want to shift problems from urban to rural areas by only regulating the urban sources. While the standards are set based on urban priorities, they will be presumed to be national.

In response to the question about how many HAPs have quantitative health data, Ms. McKelvey said that 160 of the 188 have some quantitative information, including data from IRIS, CARB data, and other EPA sources. With respect to bioaccumulative toxics, Ms. McKelvey said that EPA received comments that they should be on the list, and four pollutants (PCBs, HCBs, and two others) were added.

2.0 MONITORING SESSION (*Moderator: Mel Zeldin, CARB*)

2.1 History of HAPs monitoring

Eric Fujita, DRI

HAPs Ambient Monitoring Programs

- NMOC and UATMP began in 1984
- PAMS
- $PM_{2.5}$ and PM_{10} Speciation Network
- Field study measurements of VOCs and PM

Ambient trends from 1982 -1993

For various sites in LA and other urban areas around the country, there has been a downward trend in NMHC concentrations, related primarily to mobile source controls. Other criteria pollutants (CO, lead, NO_x, ozone, PM_{10}) have also shown an overall improvement.

Benzene showed good progress, particularly from 1995-1996 when reformulated gas was introduced. C9 and C10 aromatics, diethylbenzenes, methyl chloroform, carbon tetrachloride, and 1,3-butadiene also showed an overall downward trend, although formaldehyde shows a slight increase. Unlike benzene, there was a higher concentration of formaldehyde in the afternoon, suggesting more formation in the atmosphere. Details of these and other ambient measurements can be found at http://www.arb.ca.gov/aqd/toxics.htm. The speaker was not aware of any statistical analysis conducted on these trends.

Source Contribution Estimates

Data from a Denver study suggest that $PM_{2.5}$ emissions from gasoline vehicles have been underestimated, with cold-start operation and high-emitting vehicles contributing much more total carbon than expected. In particular, high-emitters emit more of the higher molecular weight PAHs. This study used vehicles specifically recruited for the study. There were summer and winter sampling programs, with each car tested in the winter both outdoors and indoors on a dynamometer. While the altitude in Denver could affect the outcome, it is otherwise representative of most US cities.

Wood smoke was found to have a substantial amount of benzene and toluene.

Monitoring Issues for Exposure Assessment

- What sampling and analysis methods are available? (specificity, sampling artifacts, accuracy and precision)
- What is the temporal variation (diurnal, weekly, seasonal, annual)
- Are there spatial gradients (residential, commercial/industrial)

2.2 Current Status of Measurement Methods

Tom Kelly, Battelle

Dr. Kelly reported on a survey of measurement methods for hazardous air pollutants, in which measurement methods are categorized three ways: (1) applicable methods (reasonably established for use in ambient air), (2) likely methods (not yet fully established), and (3) potential methods (considerable development required). Of 188 HAPS, 134 have applicable methods. 43 have likely methods. 11 have potential or no methods. 31 of the 33 high-priority urban air toxics have applicable methods.

Issues

- Extent of implementation of methods: for example, TO-15 is applicable in principle for all 15 VOCs on the high priority air toxics list but it's not yet being used.
- Consistency of implementation of standard methods: for example, when Kelly's group interviewed people using TO-11A for carbonyl sampling in PAMS, they found that even people using TO-11A were doing it in very different ways.
- Applicability of standard methods for individual HAPS: for example, TO-15 is said to be applicable to measurement of ethylene oxide, but the stability of that compound in a sampling canister has not been adequately tested.

- Ambiguity of CAAA HAPs list. (For example, "coke-oven emissions"; metal compounds that don't specify phase or chemical speciation; hexachlorobenzene listed as a VOC when it's only semi-volatile.)
- Detection limits needed for risk-based monitoring.
- Cost and complexity of some methods, such as TO-9A, TO-10A, and TO-13A, and chemical speciation of metals.
- Spatial and temporal monitoring issues include time resolution needed to assess acute vs. chronic exposures, and the spatial scale of representativeness.

Kelly reviewed the 1989 Columbus HAP study. Measuring for 78 diverse chemicals including 19 high priority air toxics at six different urban sites, they looked at the sources of variability. Results for six air toxics from the high priority list were shown as examples. Measurement variability was low for four VOC species, but relatively high for formaldehyde and acetaldehyde. Spatial variability was small for all six chemicals, and temporal variation was relatively small for all six chemicals except benzene. For most chemicals, random noise (simultaneous variations in both time and space across the sampling network) accounted for much of the total variability observed. One aim of the study was to determine how representative a measurement from one site would be for another location in the urban area. He discussed two examples: measurements for carbon tetrachloride (which has a long residence time and little variability) can be extrapolated to a site 5 km away with confidence, whereas for formaldehyde (a reactive chemical with many sources), extrapolation to that distance can be done only within about a factor of 3. He also described another way to look at short-term variability by using the daily peak to median ratio. The atmospheric lifetimes of the 33 high priority toxics were also discussed; 7 of the 33 have lifetimes less than one day, and some may themselves be formed as products of the reactions of other toxics.

Kelly's recommendations are to further clarify and prioritize a short list of urban air toxics; to very closely prescribe monitoring methods; and to look at temporal and spatial variations in different areas.

Discussion

Much of the discussion focused on the need for data and the use of data. EPA's Air Toxics Monitoring Concept Paper calls for two monitors in each of 20 cities over the coming years. Kelly was asked if he would recommend sampling in fewer cities with more monitors each. He suggested that the two initial sites be used to look at local variability to indicate if more sites are needed. With respect to censored data (datasets with many non-detect values), Kelly wasn't sure how they're handled for exposure assessments. One participant commented that NDs can be considered to be at the detection limit for a worst case scenario. One viewpoint is that the limit of detection can be considered a boundary between estimable risks and *de minimis* risks. In addition, the use of the data matters. For instance, spatial variation is very important for environmental justice issues. However, temporal variation may not be as important in long-term exposures to carcinogens.

2.3 Summary of the June 1999 Workshop on Monitoring

Alison Kerester, NUATRC

EPA’s draft strategy said that monitoring data are needed to characterize risk, validate models, assess effectiveness of regulatory programs, etc. However, the draft didn’t address public/private monitoring networks, state monitoring, or the relationship between personal exposures to air toxics and ambient measurements. So the June 1999 workshop was held to address these issues and understand the needs for and uses of air toxics monitoring data from the perspective of various stakeholders. About 120 people

attended the two-day workshop. A consensus was formed about the need to focus on goals for doing the monitoring, and the overwhelming view of workshop participants was that the primary goal should be to determine personal exposures to air toxics. Another goal would be to improve the links between modeling and monitoring. A variety of issues were identified, including the integration of research and regulatory efforts, general population exposure vs. micro-environmental exposures, and data quality vs. data quantity. Research needs identified include health-based values for cancer and non-cancer effects, general health effects research, speciation of air toxics metals, complete evaluation of existing data, link between monitoring and actual risk, national network vs. "hot spots," micro-environmental exposures, and potential for exposures vs. actual exposures. The next steps identified at the workshop were creating a follow-up workgroup, developing a website to inform stakeholders, and continuing to exchange ideas.

2.4 Panel Discussion: Future Needs and Plans

Development of Air Monitoring in Texas*: Jim Price, TNRCC*
State Perspective of EPA Conceptual Plan: *Richard Valentinetti, Vermont Air Pollution Division*
EPA Perspective on Monitoring: *Laura McKelvey, EPA*

Jim Price began by describing the air toxics monitoring program in Texas. There are 45 sampling sites in 18 counties, with 24-hour samples taken every 6 days. There are PAMS sites, an industry-funded VOC canister network, source-oriented H_2S plus SO_2 continuous monitoring. In addition, they have portable sampling vans and labs for short-term and source-oriented monitoring. Other state air directors expressed jealousy over Texas' portable monitoring vans. Missing items in Texas's monitoring program include mercury, vapor-phase atmospheric transformation projects, most semi-volatile organics, and routine measurement of specific particulate phase organic compounds.

Richard Valentinetti gave a spirited presentation about EPA-directed and state-implemented monitoring efforts. Despite the many worthy reasons to monitor and on which program design could be based—to determine compliance with standards, because it's the law, to track trends in ambient levels, to evaluate and subsequently improve models, to establish an ambient baseline for toxic risk, and to directly evaluate public exposures—the tendency of regulators is to hide behind the law. Mr. Valentinetti likened EPA to a benevolent dictator for not consulting with state and local officials in formulating its conceptual plan. His main concern is that we not simply measure because we can. For the $30-35 million that EPA plans to spend annually, there is a strong need to focus on objectives.

Mr. Valentinetti described Vermont's monitoring program, which is funded by a surcharge on motor vehicles, and data. Vermont has a one in a million cancer risk limit for air toxics, and five years of data that indicate that the standards are exceeded 100% of the time for most compounds in Burlington, a city of just 30,000 with no industry. If this is the case in Burlington, levels above 10^{-6} risk limits will be seen anywhere in the country. He suggested that the current rush to monitor may be ill-advised given the amount of existing data that could be mined for information. There is no point in establishing 200 new monitoring stations, only to have them all provide the same data at very high operating costs, yet with great public pressure to keep them in operation. What is needed is better coordination of measurements, inventories, and models, especially considering the reality of limited funding.

Laura McKelvey, the final panelist, replied that in designing the ambient monitoring network, there is a need to look beyond urban areas in order to meet the needs of the other programs. With respect to the limited resources, she said that there is $3 million for technology and $5 million for analysis. Unlike the criteria pollutant program, however, there isn't a requirement for monitoring toxics. The workgroup being established to help design the monitoring network is looking at balancing resources and needs.

Discussion

Many participants questioned the objectives and soundness of EPA's monitoring plans. There was widespread feedback that just monitoring for the sake of collecting data isn't useful. One concern raised was that the monitoring program will only find out what we already know about sources we can't really control, and not get sufficient data from mobile sources. A 1990 EPA report about cancer from outdoor exposures found that motor vehicles and motor vehicle-related operations accounted for 3/4 of the excess cancer cases from all sources. Cars have gotten much cleaner since the 1990 report, but diesels haven't. EPA said that section 202(l) can be used to address diesel, but there is an open question as to what control strategies might be contemplated.

In reply to a question about how the air toxics monitoring network should be set up, Mr. Valentinetti said that there is a need to look holistically at all the monitoring issues. By coordinating various monitoring efforts, we could be more efficient at generating useful data. (Someone noted that a lot of money is currently being spent on a $PM_{2.5}$ speciation network, yet the guidance document mentions nothing with respect to air toxics. EPA replied that it does have a goal of getting air toxic information from the $PM_{2.5}$ data.) Another important issue is whether we're measuring the speciation and compounds that are relevant to health. There is a concern that we might begin generating a lot of the wrong data. The end game—health impacts and controls—needs to be kept in sight. It was suggested that there be a "time out," with no new monitoring for a year in order to address the goals of a monitoring program, how to achieve them, and what investments would accomplish this. This might be difficult to do given budgetary requirements. In the past, money has been squandered because it has been allocated and therefore must be spent. It would be useful if Congress could create some funding source that didn't have to be spent in a given fiscal year.

Another specific suggestion was that the special projects that Ms. McKelvey described earlier could be used to answer specific questions about air toxics. It would be more effective to conduct concentrated studies instead of trying to measure everything, everywhere. It was also noted that monitors aren't all measuring the same thing in exposure terms. A monitor in a population cluster could characterize that population's exposures from multiple sources. In order to monitor specific industrial sources, however, it could be difficult to determine where to monitor. There are tradeoffs between monitoring areas where the population is largest vs. where the concentrations are highest. Even with a perfect monitoring network, there are still presumptions about how long-term exposures relate to ambient concentrations.

The politics of monitoring was also raised. Publicly-available data from the Cumulative Exposure Project/ASPEN model created a public awareness of air toxics and a desire on the part of Congress for more data. EPA stated that their push to monitor isn't in response to Congress but rather to the many comments it received from communities that want to know what they're being exposed to. In that case, participants replied, the public should be made aware that the monitoring they're demanding is not scientifically based.

There was also discussion about the appropriateness of 10^{-6} vs. 10^{-5} as an upper bound risk estimate, and how this meshes with EPA's priority of addressing cumulative risk. Ms. McKelvey stated that that neither the Urban Strategy nor the Residual Risk Program have a bright-line risk level. Some participants suggested that 10^{-6} risk levels are difficult to relate to the public; 10^{-5} is a level people can more easily understand. Mr. Valentinetti pointed out that even with a 10^{-5} risk level, there would still be excess concentrations of benzene and butadiene, and others commented that the problem can't be solved by simply changing the risk numbers. Vermont data show that just a couple of dozen chemicals emerge as the real health risk drivers; control efforts should focus on them.

There was some discussion attempting to clarify cumulative risk and aggregate risk. Cumulative risk typically represents all pollutants that have a common mode of action, while aggregate risk refers to the sum of all exposure routes for a particular pollutant. This distinctions are important; in the case of dioxins, for example, it's important to separate out dioxin congeners because they behave differently and it makes a difference when the risks are modeled. The global approach would be to take account of total morbidity/mortality from all exposures, but this hasn't trickled down into any regulatory agency. It's questionable whether there are enough data to support this kind of analysis.

Mercury is not a carcinogen but widely discussed in the context of air toxics (it is one of the 33 EPA found to pose the biggest health risk) and highlights some of the monitoring issues discussed. EPA is currently identifying source categories, although it's not comfortable with existing ability to monitor mercury. Total mercury is monitored but speciated mercury is trickier. Mercury made the list largely because of its bioaccumulation potential, so there is a need for fish sampling, etc. in addition to air monitoring.

3.0 SOURCES SESSION (*Moderator: Glen Cass, CalTech*)

3.1 Sources of Toxic Air Contaminants

Blair Martin, EPA

Blair Martin reviewed area, point, and mobile source, with an emphasis on those affecting urban areas. EPA classifies major sources as those that emit >10 tpy of a single compound or >25 tpy of multiple compounds. The National Toxics Inventory for 40 Potential Urban Air Toxics is compiled from various sources, including TRI data. In 1993, there were 8.1 million tpy nationally, which consisted of 21% mobile sources, 18% area sources, and 61% point sources. The distribution in different states, however, varies considerably.

For urban air toxics, EPA lists between 2 and 217 source types, dependent on the particular air toxics. Emissions of various toxics, however, tend to be concentrated in a smaller number of sources. 90% of tetrachlorylethyl emissions, for example, come from only four of 179 total sources. The metals have a large number of sources, but only a few of them are significant. Organics constitute the greatest mass of air toxics, e.g. benzene, formaldehyde, acetaldehyde. Mobile sources and open burning account for the vast majority of emissions of the five most abundant organics. Emissions of other species are industry-specific (e.g. dry-cleaning, aerospace). The organic chemical industry emits a significant number of different compounds.

In response to questions, it was noted that monitored data are surprisingly close to modeled data at one New Jersey monitor. Where EPA can't verify accuracy of data, it provides many qualifiers. The 112(k) part of the inventory went through two rounds of public review. For point sources, EPA relied primarily on TRI and MACT data. For area sources, 36 states submitted inventories. Although there is a concern that the data are not as good, there has been a decrease in the reliance on emission factors.

3.2 Panel Discussion: Mobile Sources

Mobile Sources Air Toxic Emissions, Exposure, and Risk: *Phil Lorang, EPA*
Engine Manufacturers' Perspective: *Glenn Keller, EMA*
Characterization of Air Toxics: *Glen Cass, CalTech*
Diesel Particulates and Lung Cancer: *Robert Sawyer, UC Berkeley*

Phil Lorang discussed the draft emissions inventory estimates for 1996. The highway vehicle toxic emission and exposure assessment is being conducted for known/likely carcinogens, diesel PM, and special interest compounds (MTBE). The milligram/mile emission rates show a strong downward trend over time. Using this information, EPA calculated the average nationwide toxic exposure from highway vehicles, and found a large decrease in exposure from 1990 through estimated results for 2020 despite an increase in VMT. (The calculation is based on direct emissions and doesn't account for photochemistry.) Lorang reviewed the limitations and uncertainties in the data and the analytical process, noting for instance that ambient toxics data have spotty coverage and uneven methods and quality assurance, and that ambient concentration is not the same as human exposure. Some preliminary cancer risk estimates were provided for perspective only, suggesting that a small number of substances had the highest estimated individual lifetime risk. Lorang concluded by pointing out that the numbers will improve as the vehicle fleet turns over. He suggested that after-treatment and lowered sulfur content in fuel will be needed for substantial further reductions in PM from diesel vehicles, and that it would be a significant issue if diesels with current PM emission rates increased their share of the light duty fleet. Reformulated gasoline—not currently required for 75% of the country—would notably lower benzene exposures.

Glenn Keller presented the engine manufacturers' position with respect to EPA's pending decision about adding diesel PM to the list of mobile source HAPs (which they are against). Keller reported that there is disagreement over what constituent of diesel PM is responsible for health impacts and should be controlled. Control strategies would differ depending on which constituent is targeted. He also questioned CARB's listing of diesel as a carcinogen, and announced that the EMA just filed a petition for ARB to reconsider. EMA believes that the science does not support a dose-response relationship for quantitative risk assessment, and there is no consensus of scientific evidence to indicate that diesel PM is more hazardous that other PM sources. He argued that diesel engines' contribution to hazardous air pollutants is small and getting smaller as a result of existing regulations. Manufacturers have and will continue to decrease emissions over time, having already reduced particulates 90% and NOx 75% from unregulated conditions. He pointed out a number of policies and regulations affecting diesel engines and fuel already in place, that don't rely on diesel being listed as a HAP. The industry's aim is to ensure the future viability of diesel-fueled engines. Keller pointed out that they are 30-40% more fuel efficient than gasoline engines, an advantage for global warming considerations. They advocate controlling fuel quality for a variety of reasons, including the "hardware barrier" (low-sulfur fuel is needed for catalytic converters), the effect on the existing fleet, and coincident reduction of VOCs.

Glen Cass discussed his work on the characterization of toxic air contaminants from different sources, describing a vehicle exhaust sampling and characterization system. He said a great diversity of compounds is emitted in diesel exhaust, with diesel particulates typically in the 0.1 - 0.2 μg in diameter. He uses a material balance approach to assess the constituents in the vapor phase, semi-volatile vapor phase, and particle phase. He has also looked at PAH emissions from non-catalyst-equipped vehicles, which swamp emissions from vehicles with catalysts. He also described applying the mass balance approach to other sources, such as fireplace combustion of pine wood, char-broiling meat, etc. Finally, he talked about aldehyde emissions. Since aldehydes constitute a large fraction of the gas phase by mass and are significantly added to by atmospheric reactions, he believes they deserve more attention—particularly since concentrations have increased as a result of gasoline reformulation.

Concluding the panel presentations, Bob Sawyer discussed studies of diesel particulate and lung cancer. There are about thirty studies of occupational risk of lung cancer, showing a consistent relative risk of 1.3 to 1.5 for people who work with diesel engines. California assigned a potency (similar to numbers discussed by Phil Lorang) of 1000-3000 per million lifetime risk of getting cancer from diesel. However, the HEI assessment came up with a different conclusion. They found that as exposure increased (over time), risk decreased, and concluded the study shouldn't be used. (The findings were hard to explain. Perhaps there is a "healthy survivor" effect occurring.) The Teamster study had its own deficiencies, with questions as to what the truckers—as compared to the general public—were really exposed to. Sawyer noted that the US diesel fraction of highway fuel has substantially increased since 1950 (from <2% to almost 20%), mostly due to the expansion of the heavy duty truck fleet and the conversion of medium duty vehicles from gas to diesel. He said that while there aren't enough sound data to quantify the risk, there is enough consistency in the studies' findings that we should be concerned.

Discussion

CARB defended its position on diesel carcinogenicity by pointing out that based on nine years of study, a very qualified scientific panel concluded that the risk assessment was reasonable given the uncertainty. It is unlikely that the designation will change in response to EMA's petition.

Glen Cass' remarks about aldehydes drew some discussion. If aldehydes are a concern but so little of what we breathe comes out of a noticeable source, how can we control for it? Cass answered that aldehydes are ubiquitous; they react and other things react to form them. Not unlike ozone, it's a multiple-source urban air contaminant that is chemically reactive. Little is knows about the secondary reactions. As for health effects, an inconclusive smog chamber study indicated that the reacted mix was more mutagenic.

PM emissions from gas vs. diesel vehicles was discussed, with attention given to studies indicating that high gas emitters have comparable particulate emissions to improved diesels. Drivers of older high emitters might have higher exposures, and there is a higher proportion of high emitters as well as higher ambient concentrations in the poorer sections of Los Angeles. Hence it becomes a political issue. Is there political will to get the 10% of high emitters off the road given that it's possible to identify them? A similar question of high emitters was posed with respect to diesel vehicles. Apparently diesel engines have a longer lifetime in terms of mileage, but in actual usage, they tend to move from high-service to low-service uses as they age. The bigger engines are often rebuilt to current standards. In addition, many old US vehicles end up in Central America, where air pollution is significantly worse.

The role of states in generating emissions inventories was brought up, with state representatives remarking that EPA doesn't make sufficient use of state data. Lorang replied that vehicle emission rates do use state Mobile (the mobile source emission inventory model) files and data, but EPA didn't specifically ask states to provide data. However, he pointed out that the inventory is for range-setting rather than regulatory purposes.

Experience in Europe was briefly discussed. European tax policy favors diesel; in some countries as much as 50% of light duty vehicles are diesel. Now, however, they're finally becoming more aggressive about diesel pollution and characterizing fine particulates. Euro 4 levels will likely mandate particulate traps by 2005. Some countries are beginning to create incentives for non-diesel vehicles or city-quality clean diesel. Germany has a tax that increases as a vehicle ages.

Finally, the cost of controls vs. effectiveness was raised. New car emission standards are so low already that it doesn't matter if they are cut in half. What matters is in-use vehicles, on-board diagnostics, etc. Also, significant reductions will be realized as on-road technology migrates to off-road vehicles.

4.0 RISK ASSESSMENT SESSION (*Moderator: Philip Hopke, Clarkson University*)

4.1 Panel Discussion: Risk Assessment

Assessment Tools: *Jim Price, TNRCC*
Quantitative Analysis of Variability and Uncertainty: *Chris Frey, North Carolina State University*
Education and Outreach: *Gil Omenn, University of Michigan*

Jim Price reviewed assessment tools for monitoring and exposure assessment, epidemiology, and toxicology. Monitoring and exposure assessment tools are available for many compounds and mixtures, but most atmospheric transformation products are unidentified. Epidemiology tools are available for many high volume industrial chemicals and mixtures, but are essentially unavailable for transformation products. Toxicology tools are available for a small number of identified atmospheric transformation products, however, most products haven't been identified. While the overall quality of quantitative risk assessment is good for many substances, it is not adequate for transformation products. However, a comparison of gas- and particle-phase mutagenic densities before and after irradiation showed that gas phase mutagenic density ballooned, suggesting that we shouldn't ignore atmospheric transformation products. There are three candidate approaches to assess the significance of total pollutant burden including atmospheric transformation products: (1) studies of populations living in areas with different pollutant concentrations, (2) life-time animal exposures, and (3) chronic animal exposure to concentrated ambient PM.

Chris Frey presented a quantitative approach to analysis of variability and uncertainty in exposure and risk assessment. Variability arises from real differences among members of a population. Uncertainty arises from lack of knowledge regarding the true value of a quantity, such as a statistic (e.g., mean) or distribution of inter-individual variability. Sources of uncertainty include measurement error, random sampling error, non-representativeness, and lack of data. Variability reflects the certainty that different individuals will have different exposure or risk, whereas uncertainty reflects the probability that exposure or risk for any individual will be over- or under-estimated. Knowledge regarding variability can be used to identify highly exposed or at-risk subpopulations that might merit additional study. Knowledge regarding the key sources of uncertainty in an assessment can be used to target additional data collection or research to reduce uncertainty in predictions of exposure or risk. Both variability and uncertainty may typically span several orders-of-magnitude in assessments of emissions, exposures, and risk. Quantitative probabilistic analysis can be used in assessments to properly quantify the state of scientific knowledge and to provide important policy insights regarding highly exposed subpopulations and key sources of uncertainty. There are several tiers of analysis, including point-estimate, sensitivity, conventional one-dimensional Monte Carlo simulation, and two-dimensional Monte Carlo simulations, that can be used in series as needed for different purposes (e.g. screening, research planning, regulatory decision-making). Dr. Frey presented an example case study featuring a 2-dimensional simulation framework in which variability and uncertainty were distinguished and propagated through a model to predict hazardous air pollutant emissions from power plants. Additional information about his work can be found at http://www4.ncsu.edu/~frey/ .

Gil Omenn addressed the issue of education and outreach about air toxics. He began by describing an incident in the mid-1980s where a public presentation was made about risk from arsenic to justify the need for costly controls for a copper smelter plant in Tacoma,WA. The public's questions were very

pragmatic, e.g. could they eat vegetables from their gardens? However, these issues weren't part of the risk assessment. "Risk communication" must be a two-way process, with both parties listening and explaining. He said that he realized that they needed to better match the information citizens need to what risk assessors produce. Statistical analysis is useful for policy making, but not necessarily for conveying information to the public, and he explained a number of reasons why this is so.

Drawing upon the report of the Presidential/Congressional Commission on Risk Assessment and Risk Managment (Omenn Commission), he pointed out that risk assessment is just one part of *risk management*. In the Commission's framework (http://www.riskworld.com), the six steps are: put each environmental problem into public health and ecologic context; identify and quantitatively estimate risks; identify and evaluate options; make decisions; implement those decisions; and evaluate the impacts. Stakeholders need to be in the midst of this process, preferably from the beginning of step 1, in order to build more public confidence in regulators' agenda and methods. Omenn went on to discuss the many difficulties of the risk assessment and risk management for air toxics. There are both multiple sources and multiple effects for a given chemical, multiple chemicals that produce the same effect, and multiple media that people may be exposed to. There are both cancer and non-cancer effects. There are also legal constructs complicating the picture: the Clean Air Act places criteria pollutants and hazardous pollutants in two different categories even though many sources emit both types. For criteria pollutants, the margin of exposure between the protective standard and actual exposures is very close, but for HAPs it is often five orders of magnitude from concentrations that produce tumors in animals or workers. He highlighted this asymmetry, or imbalance, and questioned the logic and public health benefit. He also raised issues of indoor vs. outdoor pollution, and competing non-environmental public health concerns (e.g. well-baby care vs. pesticide exposures in children). Overall, he concluded, a big challenge is to figure out and control attributable risks for common diseases.

Discussion

The discussion began with the issue of voluntary vs. involuntary risk. This is very important to people, as exemplified by public resentment of the comparison between industrial pollution and smoking.

Whether to test and regulate mixtures is an issue with disagreement among scientists. Omenn believes that testing real-life mixtures is good regulatory science. If something is found, subsequent investigations can aim at identifying the potent fraction. But we don't have to understand everything to take public health action; if there is public exposure to a mixture, we don't need to wait to delineate every part of it.

Public perceptions were also discussed further. Simply labeling chemicals as toxic or not conceals degrees of potency, and the public has difficulty delineating degrees of risk. Population vs. individual risk is difficult to communicate, as is the hypothetical 70-year exposed individual. One participant raised the practicality of doing quantitative risk assessment when such broad intervals of potential risk result when variability and uncertainty are factored in. It was noted that this is not a fault of uncertainty analysis but a reflection on the state of the knowledge. It's a policy issues, not a scientific issue. When asked how he would approach $PM_{2.5}$, Omenn said that it's important to know which components we'd like to reduce, since different control strategies may have differential benefits and unintended risks. Risk assessment incorporates guesses which are really hypotheses that can be tested. Risk assessment should be seen as part of the beginning of the risk management process, rather than the end.

DAY 2

5.0 MERCURY SESSION *(Moderator: Praveen Amar, NESCAUM)*

5.1 Panel Discussion: Mercury

Public Interest Position on Mercury: *Felice Stadler, Clean Air Network*
Power Plant Mercury Control: Issues and Options: *Dr. Ramsey Chang, EPRI*
New Jersey Mercury Control: *Bill O'Sullivan, State of New Jersey*

Praveen Amar introduced the panel discussion with the EPA 1998 Report to Congress on Utility Air Toxics, which concluded that "Mercury from coal-fired utilities is the hazardous air pollutant of greatest potential concern." The New England Governors and Eastern Canadian Premiers have an action plan with an overall regional objective of reducing mercury emissions by at least 50% by 2003. In the plan, they identify control options and/or recommend emission limits for MSW combustion, medical waste incineration, sludge incineration, and utility and non-utility boilers. The Commission for Environmental Cooperation (CEC) issued draft policy recommendations in April of 1999. The key recommendation is technology-forcing standards for coal, with a multiple-pollutant approach and performance standards for existing boilers.

As the first panelist, Felice Stadler reviewed the problem with mercury. 40 states have issued fish consumption advisories because of mercury contamination of freshwater and marine fish. Electric utilities are the largest source, and from 1992-1998 the use of coal plants increased nearly 16% nationally and more than 40% in some states. She described the Clean Air Network's national campaign, which focuses on removing the loopholes in the CAA for power plants. They conducted a campaign focusing on TRI and right-to-know data, and analyzing the data for how many children live within 30 miles of the dirtiest plants. Utilities acknowledge that they emit millions of pounds of chemicals but say they don't cause any harm. CAN got press coverage, however, and raised significant public interest in the issue. There is an EPA proposal to lower limits that trigger reporting requirements.[1] She finished by reviewing CAN's policy recommendations to develop stringent national multi-pollutant emission standards and require all plants to meet modern standards. These safeguards are needed given past and projected coal use trends, and can set the stage for other pollution controls.

Ramsey Chang addressed more technical issues of mercury controls for power plants. Since mercury is present as a vapor in flue gas at the ppb level, control is difficult. Reliable methods to sample, measure, and speciate mercury are still under development. Many engineering aspects are not well understood, including unintended consequences on the functioning of the power plant and other controls and stability and disposition of waste products. Chang reviewed EPRI research in mercury removal options, describing various possible approaches and providing examples of the technical and cost issues related to them. The control strategies include sorbent/chemical injection, coal cleaning, plasma corona discharge, bed/reactor sorber, and scrubbing. In assessing the cost effectiveness of mercury control, they look at low life-time cost (capital vs. operations and maintenance cost, impact on other power plant components, retrofit ease) and robustness (applicability to a wide range of sites, integration/compatibility with other pollution control).

[1] The New England/Canadian Task Force is on record requesting a TRI limit lowered by a factor of 10 (1 lb annual emissions lowered from the current 10).

Bill O'Sullivan reviewed New Jersey's success to date with mercury reduction. Its Mercury Task Force had success with emissions from MWCs (reduced emissions of 4500 lbs/year down to about 300) and is now focusing on coal and other sources. The biggest source is breakage and volatilization during MSW handling, followed by steel and iron manufacturing. He reviewed other sources also. In New Jersey, medical waste incineration is only a very small contributor due to their program to eliminate mercury use in hospitals. They have achieved a 90-99% reduction without using controls on facilities themselves. His message was that despite difficult characteristics, mercury can be controlled, and that controlling the waste stream sources is important. EPA's air and waste staff need better communication and planning, he emphasized. The historical perspective he provided indicated that an active environmental group, progressive county government, and early commitment to a state standard contributed to the success New Jersey has had controlling mercury emissions. O'Sullivan also reviewed data showing performance at various facilities. Based on these results, his conclusions were that mercury content of MSW is highly variable, waste management works[2], carbon is highly effective (the more the better up to a point), and baghouses are better than ESPs.

Discussion

The discussions addressed a wide range of topics, as reflected in the diverse presentations. Participants commented on CAN's right to know campaign, commending their efforts. It was suggested that they use their network to convey information such as less need to worry about MTBE. It was noted that the TRI reports for this year will provide a lot more information about toxic air pollutants emitted by electric utilities. The deadline is July 1, and the data are now being gathered. However, since the reporting thresholds remain very high, emissions of mercury will likely not be included until EPA lower the reporting threshold (projected to affect 2000 TRI reports, which won't be compiled until Spring 2001).[3] The national mercury inventory won't be publicly available until spring of 2000.

Trading issues were raised. CAN is against mercury trading because there are local impacts. In addition, it sets a bad precedent for how to deal with toxics more generally. (CAN is generally opposed to toxics trading.) Local impacts cannot be adequately addressed with trading schemes. Many others working on reducing mercury emissions don't support trading. It was also noted that breathing is not the biggest exposure route for mercury, and since it bioaccumulates, just moving the source doesn't make the problem go away.

Other market mechanisms were discussed. Tax incentives for fuel switching can be used. Sources other than coal combustion were discussed. In areas that don't burn coal or garbage, there are smaller combustion sources, and some indirect evidence from Canada that mobile sources may be significant. Crematoriums also are a significant category. San Francisco Bay sediment is heavily contaminated, and there are possible emissions from refineries.

There were some technical questions related to Ramsey Chang's and Bill O'Sullivan's presentations. Notable was that Chang thought that CEC's three to five year timeframe for mercury control was reasonable, but will not be easy. He was cautious because of the many unintended consequences EPRI researchers have been encountering. He agreed that a full-scale demonstration project would be needed, but that this requires tremendous resources. There is much concern about which technology is chosen,

[2] Facilities ranged from 100 to 2000 ug/m3 of mercury emissions before waste management, and 1-50 ug/m3 after.

[3] On a separate effort, EPA is requiring utilities to collect information on mercury content in coal, and a select group of plants is going to run stack tests this year. All this information will be collected by the summer of 2000, and will be used to generate more exact emissions factors, and in turn, a more complete mercury emissions inventory for the utility sector. EPA will rely on this information when making its determination on whether to regulate mercury emissions from utilities (projected decision December 2000).

because if it works, there will not be resources to test others. DOE is supposed to come out with a solicitation to encourage a full-scale demonstration. With respect to getting mercury out of consumer products, O'Sullivan replied that EPA needs to become more active. There is legislation promulgated in most Northeast states in the early 90s banning mercury in packaging, and they are now working on a model for consumer products as well.

6.0 EXPOSURE SESSION (*Moderator: Larry Cupitt, EPA*)

6.1 Exposure Assessment to Air Toxics

Clifford Weisel, EOSHI

Cliff Weisel gave an overview of the field of exposure assessment and how it fits in. We need to connect air toxics in the environment to potential health outcomes. The science of exposure assessment is a critical component of establishing or disproving the link. Weisel provided some definitions. Exposure assessment is defined as the science that describes how an individual or population comes in contact with a contaminant, including quantification of the amount across space and time. Exposure is contact with a chemical, biological, or physical agent at the boundary of a body at a point in space over a specified time. The route is how a substance contacts the body (e.g. ingestion, inhalation). The pathway is the path the substance takes from source to exposure. A basic principle is that exposures are multimedia—air toxics do deposit onto water, food, and surfaces, providing potential exposures through ingestion and dermally. Inhalation is the primary exposure route for most air toxics.

Exposure assessment is used in risk assessment, status and trends, risk management, and epidemiology. Models account for how individuals move through different microenvironments and the concentrations in those environments. Weisel described the modeling process and components, and why we shouldn't limit the analysis to outdoor air. Most people spend less than one hour daily outside. He reviewed the TEAM (Total Exposure Assessment Methodology) study, which had a working hypothesis that indoor exposures would dominate. It found that for a variety of compounds examined, particularly air toxics, the air concentrations measured using personal samplers exceeded outdoor air concentrations measured near the homes of the participants. Breath samples indicated that exposures in some cases were higher than amounts in the ambient air. The conclusion was that indoor sources were the dominant contributor to indoor and personal air for a majority of air toxics measured. Results also indicated that ambient sources were not the sole contributor to indoor concentrations.

Weisel also reviewed various studies on variability and indoor/outdoor residence times, including NHEXAS (National Human Exposure Assessment Study) and RIOPA (Relationship among Indoor, Outdoor, and Personal Air). In the latter study, homes near sources are being examined to establish the ambient contribution to indoor air levels. Summarizing, Weisel, stated that exposures depend on time and activity patterns; indoor concentrations exceed outdoor concentrations for many air toxics; the contribution by ambient sources to air toxic exposures is still to be defined; and the potential exists to measure and model a population-based exposure distribution—but not if all the money is dumped into outdoor monitoring.

Discussion

The discussion focused on personal exposures and how they are assessed. More personal sampling has been conducted for VOCs than for PM. Characterization of the organic components of PM have not been done. People wear monitors for 48 hours. They use questionnaires for some projects to account for where in the house exposures occurred. Models use respiratory rates for calculating dose. For source

apportionment, information regarding activities is used to see what is common to higher exposures. A small source near a person (for example cigarette smoke) can affect personal exposure greatly even if the contributions to the ambient concentrations from that source are not high. Photocopiers can cause high personal exposures to toluene, xylene, etc.

6.2 Relating Risk to Exposure—Diesel Exhaust

Tom Smith, Harvard

Prof. Smith began by remarking that we intervene at the source level, not the population level. Therefore, to know how much intervention is needed, we need to know how much exposure produces how much risk. The research question is: What evidence is there that X is associated with an increase in risk of Y? (The cause is left as a black box.) Of more than thirty studies of diesel-exposed occupations, most indicate that there is a relative risk of 1.2 to 1.5. But only three of these studies estimated exposures, and these used crude markers.

There is a question as to what exposures assessment should measure. The nature of diesel exposure is that it is a complex mixture with variable composition of particles, gases, and vapors, and diesel engines are not the sole source. Alternative methods for determining what to measure include animal testing, but there are problems with this method ("Humans are not just big rats" etc.). Smith proposed a new hybrid research approach that would combine epidemiological research dealing with characteristics of health effects in human populations with agent-based exposure assessment to estimate individual exposures. There are new tools, such as biomarkers, that can be used. Smith explained that dose relationships allow the connection of personal/population exposures to disease/effect and population risk.

In conclusion, Smith noted that quantitative exposure-risk relationships cannot be developed by traditional epidemiology (exposure specification is the problem). Toxicologically-based exposure assessment can specify the "dose" part of the relationship. Much more detailed, repeated measure designs are needed to provide the necessary raw data for risk assessment. Hybrid prospective individualized exposure assessment and epidemiologic field studies can provide the dose-risk data needed for standards.

Discussion

The discussion explored these issues further. With respect to diesel particle size, toxicity data suggest that very small particles are riskier. However, this is a difficult thing to measure, and a dose metric is needed. A system approach is needed because the location of the person relative to the source of diesel exhaust matters. Diesel exhaust is emitted as very small particles, but in the general atmosphere, they become aggregated with particles from other sources and grow larger, which affects their deposition. There also are no good biomarkers for diesel exposure nor its early effects. The time lag for cancer is long, so a biomarker of early effects would be valuable to indicate potential risk from current exposures. (Current cancers are associated with exposures 20 years ago.) There may be some useful findings from an on-going prospective study which is attempting to determine how predictive biomarkers of genotoxic effects, such as chromosomal aberrations, are for cancer risk. Unfortunately there has not been a long-term exposure-based, prospective, longitudinal study of a large population like the Nurses' Health Study. The Nurses' Study has been very successful using repeated determination of diet and other life style variables by questionnaire, but has not attempted assessment of environmental exposure which require complex and expensive measurements.

7.0 HEALTH EFFECTS SESSIONS (*Moderators: Debra Kaden, HEI Leonard Levin, EPRI*)

7.1 EPA's HAP Priority Setting Methodology

Charles French, EPA OAQPS

Charles French described the approach EPA used for HAP ranking and selection as part of the Urban Toxics Strategy. CAA section 112(k) required EPA to identify at least 30 HAPs that pose the greatest threat in the largest number of urban areas as a result of area sources. EPA conducted a complicated integrated analysis of emissions data, air monitoring data, current toxicology information, previous hazard risk studies, and data from the Cumulative Exposure Project (CEP) study. The three primary ranking methods were (1) OAQPS ranking analysis, (2) CEP analysis, and (3) previous study analyses. French described each of these in detail. For previous studies, 14 out of 23 were selected. The CEP study (http://www.epa.gov/oppecumm/air/air.htm) used a dispersion model for 148 HAPs for all census tracts in the US and compared modeled to benchmark concentrations. The OAQPS analysis combined various exposure surrogates, for example risk-based concentrations, bioaccumulation factors. EPA integrated the lists from these three ranking methods, and selected HAPs that either (1) were identified in two out of three or (2) were identified by one analysis to have area source emissions greater than 25% of the total based on a publicly-reviewed emissions inventory. The result was 33 urban HAPs, 30 of which are the highest area sources. They found general agreement among analyses, suggesting correct resulting priorities and a sound overall approach.

Discussion

The review process was questioned. Although CASAC didn't review the approach, a peer review panel in 97-98 did, and there is public review as part of the draft strategy. It was suggested that EPA look at whether any compounds would be dropped if the largely rural communities were eliminated. Two compounds—toluene and xylene—were dropped for another criterion, lack of peer-reviewed inventory.

7.2 Biological Effects

Roger McClellan, CIIT

Roger McClellan began by stating that he is increasingly concerned about how we're using quantitative risk analysis. Will we make decisions based on acceptable risk or acceptable level of control technology? We should do quantitative analysis to inform decisions rather than to make them, because there is always a need to apply judgment. Unfortunately, there is a terribly inadequate database for doing quantitative analysis of exposure and dose-response, yet we tend to get carried away with mathematical gymnastics. He acknowledged that what EPA did was necessary but reminded people to remember that the bottom line is to inform a judgment. He cautioned against believing any of those numbers.

McClellan then reviewed historical trends of concern over disease, including the emergence of cancer and other diseases with different exposure models.[4] There is an inherent challenge in protecting against carcinogens with ample margin of safety. The 1990 CAAA shifted the approach to extrapolating (from lab animals etc.) to below the region where health risk can be measured. McClellan believes that the current risk paradigm is adequate to inform decisions, but we rely too much on it. The default

[4] See McClellan, R.O. 1999. "Keynote Address: Human Health Risk Assessment: A Historical Overview and Alternative Paths Forward," *Inhalat. Tox.* 11: 477-518.

assumption, he said, is that chemicals act in a linear manner down to low doses. However, there is a high dose phenomenon, and different chemicals have different mechanisms of action.

Now, we are about to embark on a major campaign to test for hazards, with continued controversy over quantitative risk analysis. Meanwhile, other fields in the life sciences are racing ahead (gene expression, etc.), and may provide powerful tools for identifying hazards. Some of the essential ingredients for regulatory decision making are statutes that are appropriately directive and scientific information that informs decisions. In summary, he said that it's always easier to identify hazards than to quantitatively characterize risk. He questioned society's willingness to spend the money needed to get the information for doing this, and said that the current system isn't working. Without a new approach, the emphasis by default will be on hazard identification and battles over competing hazards.

7.3 Cumulative Assessment Program

Tim Hunt, API

The Cumulative Exposure Project is laudable for its ambitious goals, but has many problems in its current formulations. The CEP models ambient concentrations; it is not a measure of public health risk. Preliminary results show that 8 HAPs exceeded 10^{-6} benchmarks across the country, however many fewer areas around the country exceeded the 10^{-5} and 10^{-4} benchmarks. Urban areas have the highest predicted concentrations and mobile sources tend to be the largest single source. Focusing on benzene, 1,3-butadiene, and formaldehyde, he showed mapped data for people by county exposed to these at different risk levels.

EPA chose not to put CEP information on the web for fear that the public might reach "inappropriate conclusions." However, EDF put it on the web anyway. EPA's next steps are to have the National Toxics Inventory completed by October, rerun the ambient concentration model in December, and incorporate dispersion factors in February. In April, EPA plans to complete CEP also called the National Air Toxics Assessment (NATA). Hunt reviewed some concerns with CEP, including old emission estimates, inadequate exposure estimation, and comparison of results to fictitious reference points or benchmarks that don't exist in the CAA. He concluded that CEP is not currently ready for use as a policy tool because of its inadequacies and potential to misinform the public. He also stated that the CAA is working to reduce toxics already and the CEP is a reasonable starting point to develop prioritization tools. The next steps are to continue validating the method, improve components of the model, update the emissions inventory, and remove the benchmark comparisons.

7.4 CEP, Toxic Air Pollution, and the Future

Melinda Treadwell, NESCAUM

Melinda Treadwell noted that CEP was done to determine 1990 air quality nationwide, to better characterize the problem, to prioritize future research, and to develop a tool to measure program effectiveness. The model has performed surprisingly well where compared to monitoring data. It showed that about 50% of the census tracts have 11-15 HAPs above the benchmark. One problem is that they lack significant data with respect to non-cancer health effects.

Treadwell discussed New York and Vermont monitoring data. The four major risk drivers in the region are acrolein, benzene, 1,3-butadiene, and formaldehyde. However, the majority of ambient monitoring data don't reflect maximum individual exposures. Indoor air concentrations, occupational exposures, and episodic (e.g. commuting) exposures are much higher than measured ambient concentration. She

concluded that we need more development of assessment tools and strategies that can better consider multimedia exposures and multipollutant exposures.

7.5 California Air Toxics Reports

Mel Zeldin, SCAQMD

Mel Zeldin presented the Multiple Air Toxics Exposure Study (MATES-II), which included air toxics monitoring, toxics emissions inventory, and modeling/risk assessment. It's based on one year, ten sites plus three mobile platforms for microscale study. More than 30 toxic pollutants were measured and the final report is due this summer. There has been a lot of local interest and many communities requesting local monitors.

SCAQMD has found a lot of seasonality in the data, including 1,3-butadiene (worse in the fall when there is more stagnation) and benzene. The overall cancer risk trend is downward over the 1990s, notwithstanding spatial variability. Surprisingly, the fixed sites generally showed greater cumulative risk than the microscale sites that were specifically chosen as potential hot spots. The average basin cancer risk aggregate was calculated to be 425×10^{-6}, with butadiene and benzene accounting for most of the risk. If you add a diesel component, the number jumps to 1400×10^{-6}. Other preliminary conclusions are that mobile source components dominate the risk and that local "hot spots" are not yet evident. They are going door to door to update emission inventories for the microscale sites.

7.6 EPA's 75% Cancer Risk Reduction Goal

Laura McKelvey, EPA

Laura McKelvey briefly spoke about EPA's progress on the 75% goal. They have started surveying states for what emission reductions they're getting, but it's difficult. Then, they looked at RCRA and Superfund data to identify collateral air toxics reduction benefits, but this too was not successful. They were looking at the new NAAQS but they were recently thrown out in court. The first look at risk reductions will be in the spring of 2000. The process is to improve inventories, develop research needs, and conduct a collaborative effort with stakeholders.

7.7 Risk in Perspective

Roger McClellan, CIIT

McClellan engaged the participants in a back-of-the-envelope calculation to put the cancer risk numbers in perspective. Given that one in four Americans will die of cancer, the air toxics risk of approximately 400 in a million calculated by California equates to about 0.16%—very small compared to cancer from all other causes. The temptation is to think the number is a lot bigger than this. However, very few cancers have an etiological fingerprint. Smokers are likely to die of lung cancer, but non-smokers die of lung cancer too.

McClellan asked whether people would be willing to have records from doctor visits go into a national database. If we really want to follow and understand these environmental health factors, then we need a national system of health data. Health is often sold as a surrogate for clean air, but it's very difficult to tease out the influence of low-potency compounds that have risk factors of less than 1%.

7.8 Discussion of Health Effects Presentations

It was questioned why EPA is looking at all 188 compounds for the 75% risk reduction when EPA did a good job of identifying the 30 relevant ones. It would make more sense to focus on those and formulate the research agenda to fill in the blanks. EPA responded that they are looking beyond the 33 because they were chosen on a *national urban* basis; California, for instance, might have other more important ones. That there would be more than 5-10 additional compounds on the margin was questioned.

The use of risk numbers was discussed. Even in a case such as benzene where the numbers are fairly reliable, there is still debate about how to use them. It was questioned how strategic planning would change if we had absolute numbers. One response was to identify major sources and the status of control technology. It was also noted that all these numbers should be used for guidance. Benzene reductions, for instance, have been occurring notwithstanding any ongoing scientific debate.

Another comment was that negative findings should be publicized. This would put more reality into EPA's reporting. It was also recognized that as inventory methods improve, emissions tend to "grow." (Actual monitored data do show reductions however.) When discussion inventories and percentage reduction requirements, it's important to understand the baseline year.

Some state agency representatives questioned the role states play in implementing the air toxics strategy, and there was a fair amount of discussion about what EPA is imposing on the states. One claimed that Congress didn't know enough to properly instruct EPA about doing the CEP, but acknowledged that policy makers have to do something and waiting forever for more data is not an option. But whether we are currently doing the "least stupid thing" was questioned. Others replied that generally something triggers a decision, which is then made based on best available information at that point in time. Historically, we have generally done a good job. But whether we are doing as good a job on toxics regulation is still an open question.

8.0 RESEARCH NEEDS SESSION (*Moderator: Dan Greenbaum, HEI*)

8.1 Panel Discussion: Additional Research Needs

Michael Scheible, CARB
Alexandra Dunn, CMA
Chon Shoaf, EPA
Carmine DiBattista, Conn. DEP
Glenn Keller, EMA
Jason Grumet, NESCAUM

Relatively unstructured remarks were made by the six panelists in the last session. Michael Scheible began with three points. First, that EPA should stay the course with mid-course adjustments. The public breathes a chemical soup, not single sources, and the Urban Air Strategy has the right holistic approach. The second point was that EPA should keep the focus on risk reduction. Reducing emissions will reduce ambient concentrations and exposures. The third point was to keep the focus on technology that works, industry can accomplish, and the public is willing to pay for.

Scheible also made suggestions for added technology/science work. The California monitoring program is more than adequate, and it's a waste of resources to copy the network all over the country. Some current methods are very expensive, and there are cheaper ways to get the data. Second, a lot of data

haven't been examined and there should be more effort put into collecting and analyzing existing data. Third, we also have a lot of information about inventories and don't need to redo whole inventories, but focus data needs for individual control efforts. Fourth, health analyses should gather information about exposure, body burdens, mechanism, but advances in understanding will be incremental. Fifth, there should be more resources for finding control technologies, for instance, promising diesel technologies. Sixth, our air pollution control program should be constructed holistically, because, for example, toxics, PM, and NOx all come from diesels.

Alexandra Dunn commented on focusing research needs on what we don't know, and what is important to find out. For example, *personal* exposures to air toxics is an area that needs more research. More focused research requires a plan, which EPA can develop using stakeholder input and an independent expert review panel. There should also be a monitoring network plan which clearly states the goals, time, and budget constraints, requisite level of data quality, and how to use state and other program data.

Chon Shoaf, who coordinated the development of research needs for EPA's Integrated Urban Air Toxics Strategy, presented the needs identified in the areas of exposure, health effects, risk assessment, and risk management. Exposure assessment research needs include: 1) improved ambient monitoring methods; 2) area source emission estimation methodologies; 3) more accurate non-road mobile source emission characterization; 4) development of source-based urban-scale air quality models for urban HAPs; and 5) improved understanding of the distribution of human exposures and the pathways by which HAPs reach humans. Research needs for health effects and dose-response assessment include development of statistical and mode-of-action methods for deriving acute and chronic dose-response assessments. Risk assessment needs include methods for mixtures and more effective risk communication techniques. Identification of pollution prevention alternatives were identified as risk management research needs for urban air toxics.

Carmine DiBattista made comments from the perspective of a state air director at the end of the pipeline for the decision-making process. Decisions have to be made, often quickly, and sometimes in a setting that lacks optimum information. Many times these decisions are influenced by politics, the press, public opinion, and economics. By example of this symposium, air directors need to be more directly involved in the health discussions. In this way, they can influence the level of risk information needed to act programmatically. He referred to toxics as the "sleeping giant" and "poor stepchild to ozone." A great deal of resources has been directed towards ozone attainment in the Northeast, and this effort will continue. However, there is also a need to substantially reduce toxic emissions. Mercury gives us a prime example of the needed type of commitment. The New England states and the eastern Canadian provinces are well on their way to a 50% regional reduction in mercury emissions by 2003. He went on to describe a program that the NESCAUM states (New England, New York and New Jersey) are embarking on. The state air directors have concluded that a toxic reduction strategy is merited given that air monitoring data substantiate basic CEP conclusions. Their strategy will identify priority compounds; identify sources of emissions; quantify benefits of existing and planned control strategies; identify additional reduction needs; identify federal, state, and regional responsibilities and opportunities; and identify short-, intermediate-, and long-term targets. He concluded that program decision makers need to be brought closer to the scientific community to enhance information exchanges and to establish baselines adequate to initiate program measures.

Glenn Keller made some recommendations concerning urban air toxics research needs. He called for research and improvements to be made in the areas of measurement methodology, standardized methods for sample collection and analysis. For source characterization, we need to standardize lab methods to minimize uncertainty, and focus on the characterization of current motor vehicle technology rather than 10-15 year old engines that will no longer be in the fleet. It's also important that the benefits to society

be prioritized. In addition, EPA must consider indoor air toxics and prioritize exposure controls accordingly.

Jason Grumet touched on what he called "two fictions": bright lines and independent panels. He questioned the actual usefulness of independent panels, and suggested a three-year moratorium on them. He said that such panels are never actually independent—rather, they consist of people whose biases are invisible to the "rest of us"—yet they lend an imprimatur of objectivity. He's not convinced that they're helping, and expressed more faith in the explicit, harried, uncomfortable reality of the state air directors. With respect to "bright lines," Grumet suggested that the focus on ozone is not because we know more about it, but because there's a bright line threshold (despite the chaos and uncertainty). He concluded that it's ironic that the special interests that campaigned against the CAAA and Tier 2 standards now tout them as why we don't need to do more.

Discussion

Some echoed the need to devote more resources to mining existing data. CARB has committed to getting all its data on the web, which should help. However, the fiasco over CEP indicates we need a better approach. We need to figure out how to clearly identify preliminary data as "*draft*" so that they can be available sooner and people can comment on them. Jason Grumet commented that it was EPA, not the public, that overreacted despite a lack of evidence to support their concerns, and thought it was disrespectful of the public's intelligence. It's a problem of bureaucratic distrust and unwillingness to give up control of the data, he said. There is also a need to publish peer-reviewed information about what control technologies have been tried and what's worked or not worked.

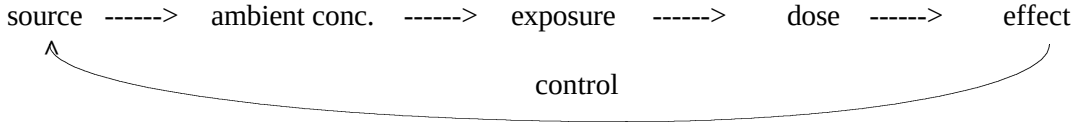
Referring to DiBattista's remarks, it was noted that not only do decision makers need to be brought closer to the scientific community, but the scientific community also has to be closer to regulators. As broad as the current research agenda is, it doesn't answer the public's basic question, which is "how safe is the air and water in my community?" There is a basic need to be able to answer these common sense questions.

As during the rest of the symposium, there were comments that it is striking how little we do about indoor air quality.

8.2 Wrap Up Remarks

Dan Greenbaum, HEI

The EPA Urban Air Toxics Strategy is a new type of undertaking because it's a *strategy*, not a rule. It sets priorities and a schedule for ongoing action. The biggest challenge is to regulate while we're still learning: source inventories are evolving and our understanding of atmospheric transformation and cumulative effects is still incomplete. The paradigm is:



Sources present a complex challenge. There are multiple pollutants, multiple sources, and we only have primitive emission characterization. Many ambient pollutants result from transformation in the atmosphere. Monitoring has provided some ambient data—showing some downward trends—but by no means enough. We need a national system, but need to be careful not to overbuild, for resources might

be better used elsewhere. There are a lot of existing data that could be analyzed. Data challenges include a lack of prescribed methods and a need to better understand variability. States need to participate in decisions concerning when and how to act.

Exposure is the connection between ambient concentrations and health effects. For toxics, there is a special need to understand indoor vs. outdoor sources and exposures. Indoor exposures are poorly understood. We need to develop source apportionment tools, and this is critical to developing cost-effective control strategies. The Cumulative Exposure Project is a major effort to address all sources, and it has come reasonably close to monitored levels. It is being brought into the Urban Air Toxics Strategy and updated (NATA). The challenges are dealing with a 1990 inventory, improving the quality of modeling, and public/risk communication. MATES II is an example of a very community-oriented attempt to do some of these same things.

Diesel and mercury are in some sense the easy cases. We understand the sources, have health data, and there is a history and technology of controlling emissions. With respect to diesel, the debate is whether its emissions constitute an air toxic or not, and how large the risk is (which can be addressed with quantitative risk assessment tools). There has been less debate today concerning what to do about it. Is it regulated as PM? As an air toxic? Resolving these issues is important for determining diesel control strategies. Mercury is a very public issue because of fish advisories and TRI data. We know the primary anthropogenic sources, and control is possible, although at a cost ("catching a few fish in a big lake").

Health effects are a key element and a major challenge in developing an air toxics regulatory strategy. There is a "miserably inadequate data set for quantitative risk assessment." Only 14 of 33 priority HAPs have potency values, and there are quantification challenges, as well as questions about mechanisms at high and low doses. Unanswered is whether we are aiming for an "acceptable level of risk" (e.g. 1 excess cancer in a million) or an "acceptable level of control" (e.g. MACT).

Finally, there are many research needs to support an overall strategy. Priorities include source characterization and inventory building, atmospheric transformation, improved monitoring techniques and standardization, exposure assessment for key indoor/outdoor toxics, and health science including biomarkers for exposure and dose-response information.

APPENDIX I: LIST OF SPONSORING ORGANIZATIONS

MIT Energy Laboratory
MIT Center for Environmental Initiatives
EPA Center on Airborne Organics
U.S. EPA Office of Research & Development
Northeast States for Coordinated Air Use Management
California Air Resources Board
The Health Effects Institute
Mickey Leland National Urban Air Toxics Research Center
U.S. DOT Volpe National Transportation Systems Center
American Petroleum Institute
Chevron
British Petroleum
Amoco
Sun Oil Company
Engine Manufacturers Association
Chemical Manufacturers Association
Electric Power Research Institute
Pennsylvania Power & Light Company

APPENDIX II: ACRONYMS

ALAPCO:	Association of Local Air Pollution Control Officials
CAA:	Clean Air Act
CAAA:	Clean Air Act Amendments (1990)
CAN:	Clean Air Network
CARB:	California Air Resources Board
CASAC:	Clean Air Scientific Advisory Committee
CEC:	Commission on Environmental Cooperation
CEP:	Cumulative Exposure Project
CIIT:	Chemical Industry Institute of Technology
CO:	carbon monoxide
DOE:	Department of Energy
EDF:	Environmental Defense Fund
EMA:	Engine Manufacturers' Association
EPA:	Environmental Protection Agency
EPRI:	Electric Power Research Institute
ESP:	electrostatic precipitator
FOIA:	Freedom of Information Act
HAP:	hazardous air pollutant
HCB:	Hexachlorobenzene
HEI:	Health Effects Institute
IRIS:	Integrated Risk Information System
MACT:	maximum achievable control technology
MATES-II	Multiple Air Toxics Exposure Study
MSW:	municipal solid waste
MTBE:	methyl tri-butyl ether
MWC:	municipal waste combustion
NAAQS:	National Ambient Air Quality Standards
NATA:	National Air Toxics Assessment (new name for CEP modeling effort and follow-up activities)
ND:	not detected
NESCAUM:	Northeast States for Coordinated Air Use Management
NESHAPS:	National Emission Standards for Hazardous Air Pollutants
NHEXAS:	National Human Exposure Assessment Study
NOx:	nitrogen oxides
NMHC:	non-methane hydrocarbons
NMOC:	non-methane organic compounds

OAQPS:	Office of Air Quality Planning and Studies
PAH:	polycyclic aromatic hydrocarbon
PAMS:	Photochemical Assessment Monitoring Stations
PCB:	polychlorinated biphenols
PM:	particulate matter
RCRA:	Resource Conservation and Recovery Act
RIOPA:	Relationship among Indoor, Outdoor, and Personal Air
SCAQMD:	South Coast Air Quality Management District (California)
STAPPA:	State and Territorial Air Pollution Program Administrators
TEAM:	Total Exposure Assessment Methodology
TPY:	tons per year
TRI:	Toxics Release Inventory
UATMP:	Urban Air Toxics Monitoring Program
VMT:	vehicle miles traveled
VOCs:	volatile organic compounds