Life Cycle Environmental Impacts

Associated with Different Fuel Options

WORKSHOP REPORT

Presented by:

National Water Research Institute

in Cooperation with:

Clarkson University

Lawrence Livermore National Laboratory

USEPA - Office of Research and Development

February 15-17, 2002

Kellogg West Conference Center & Lodge

California State Polytechnic University

Pomona, California

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FOREWORD

Since 1992, the National Water Research Institute has pioneered the application of the Nominal Group Technique (NGT) as a process for identifying, prioritizing, and developing approaches that address critical water issues. This document, as with other NGT reports cited in the Appendix B, documents the results of the 35 experts as they endeavored, during the two-day workshop, to provide answers to the workshop question: ***What are the most important issues that need to be addressed in a comprehensive evaluation of life cycle environmental impacts associated with different fuels options?***

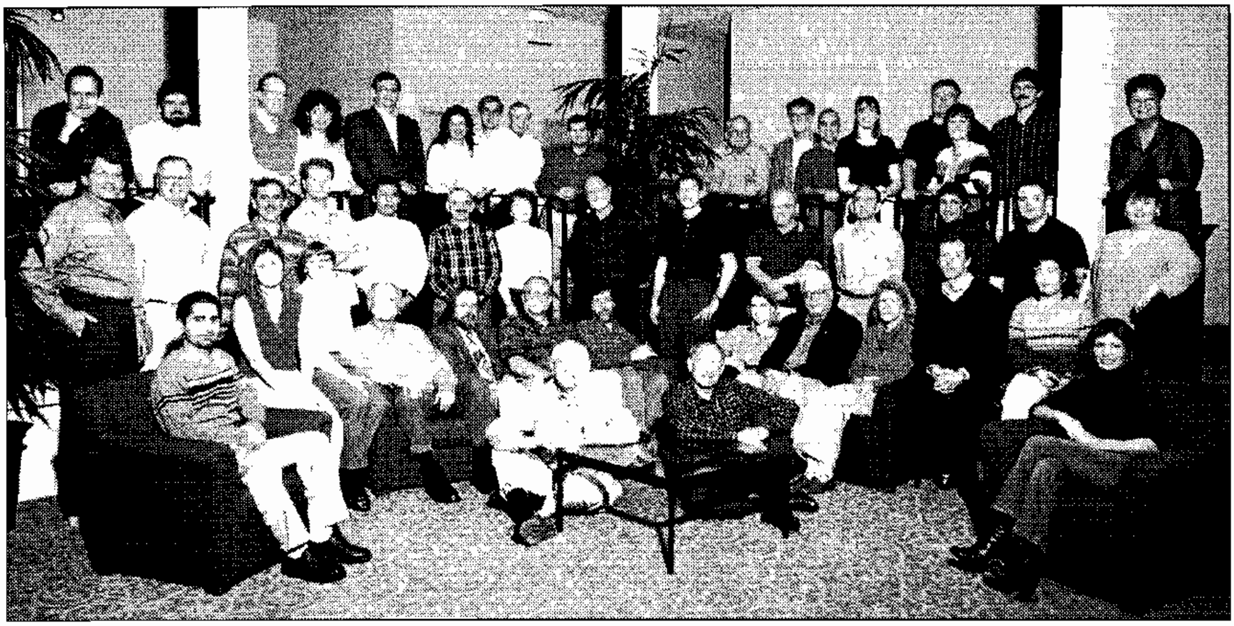
The premise under which this workshop was planned is that policy decisions must be based on a fuller understanding of the value and benefits to producers and consumers as well as those direct and indirect benefits and risks to human and environmental health. The use of such concepts as life cycle assessments is one approach to organizing and delivering data and information in a robust and comprehensive manner to decision makers. The public has often expressed its expectations to these same decision makers across the country, regarding public and environmental health issues. These expectations are often ill-formed and not based on credible science and engineering information. In many cases, this situation is due to a lack of an understanding of the integration and complexity of the multimedia nature of the problem as well as of the science and engineering parameters involved. This workshop attempted to develop a holistic approach that would provide a perspective from "cradle to grave" of different fuel options.

The success of any activity is due in great part to the participants. However, others provided the energy and vision to make the workshop happen. The Planning Committee and the "backroom crew" are singled out for providing the glue to make the event work. In particular, special thanks are extended to J. Michael Davis, USEPA; Susan Powers, Clarkson University; David Rice, Lawrence Livermore National Laboratory; Patricia Linsky and Gina Melin, Editors; Tammy Russo, Workshop Coordinator; Joe Pezely, Graphics Illustrator; Stephen Lyon, Graphics Assistant; Vahak Vartanian, Assistant; Dee Santos, Micheal Kreitz, Gulnoza Yuldasheda, Word Processors; and Teresa Taylor, Photographer. Sincere appreciation is extended to William S. Gaither, Ph.D., who, though his masterful facilitating skills, brought the NGT workshop to a successful conclusion.

RONALD B. LINSKY
Executive Director
National Water Research Institute
Workshop Secretary

CONTENTS

PARTICIPANTS

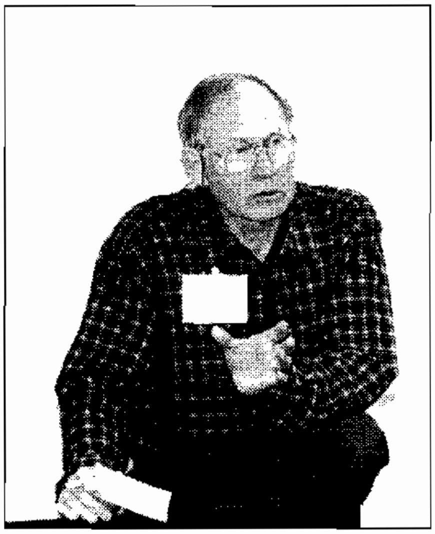


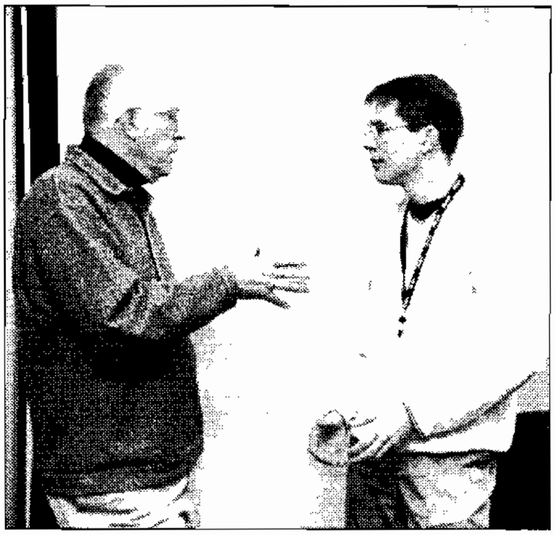
Top Row: Pedro Alvarez, Jim Davidson, Mike Davis, Rula Deeb, Cal Hodge, Donna Drogos, John Kneiss, Joe Pezely (Graphics), Michael Honeycutt, Stan Durkee, Bill Carter, Glenn Giacobbe, Deborah Adler, Rick Handley, Mary Ann Curran, Jeff Kuhn, Patricia Linsky (Editor)

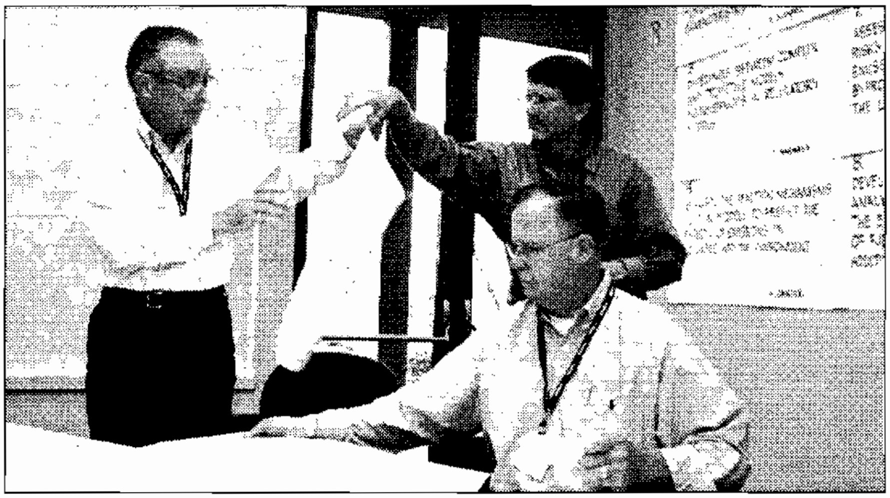
Middle Row: Stephen Lyon (Graphics Asst.) Brian Brady, David Andress, Brendan Dooher, Michael Wang, David Layton, Heather MacLean, John Shipinski, Tim Skone, Bob Reynolds, Lester Lave, Mark Delucchi, Michael Kreitz (Word Processor) Dee Santos (Word Processor)

Seated: Vahak Vartanian (Assistant), Gina Melin (Editor), Susan Powers, Walt Weber, Andy Salmon, Dave Rice, John Sheehan, Pamela Williams, Jim White, Bobbye Smith, Jeff Moller, Gulnoza Yuldasheda (Word Processor), Tammy Russo (Workshop Coordinator)

Floor: Ron Linsky (Secretary) and Bill Gaither (Facilitator).

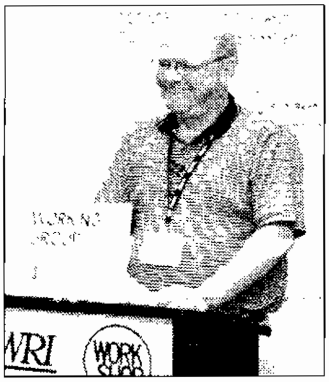






PART 1

WORKING GROUPS' REPORTS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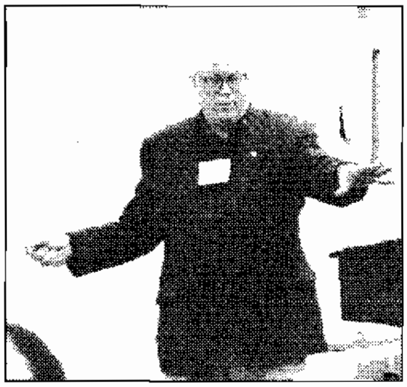

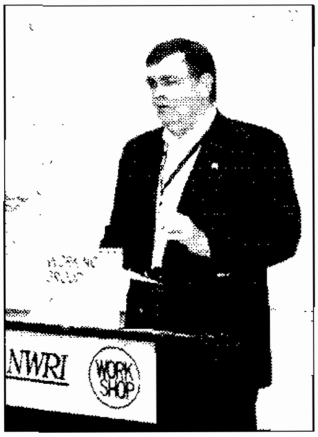
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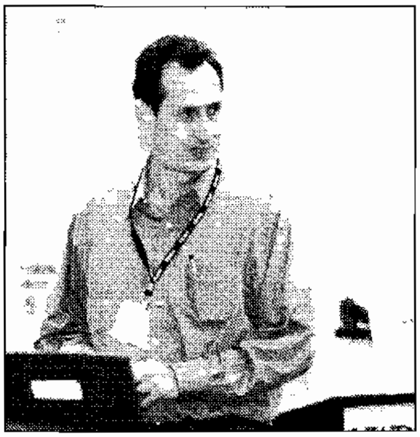


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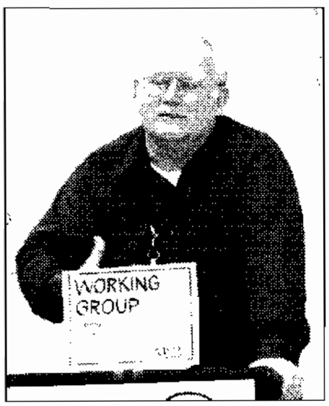
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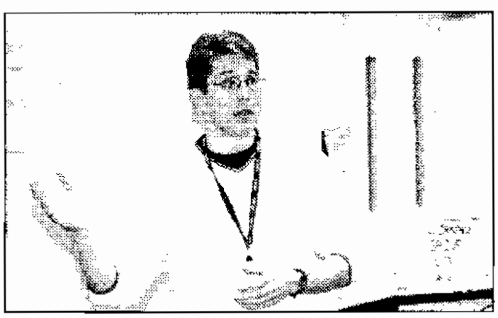


INTRODUCTION

This section contains reports that summarize and amplify each of the ten highest priority issues identified by workshop participants. The complete list of 24 priority issue areas, ranked in descending order of importance, is presented in Part 2 of this report.

Thirty-five individuals convened on Friday evening, February 15, at the Kellogg West Conference Center & Lodge on the California State Polytechnic University campus in Pomona, California. They were briefed on the Nominal Group Technique process that was to be used during the workshop.

On the following morning, the participants offered 85 responses to the workshop question: ***What Are the Most Important Issues That Need to Be Addressed in a Comprehensive Evaluation of Life Cycle Environmental Impacts Associated With Different Fuel Options?*** In the afternoon, the 85 responses were boiled down to 24 major issue areas through a process of discussion and the consolidation of similar issues. The participants ranked the 24 major issue areas in descending order of importance. What appears in this section are the reports of the ten working groups comprising three or four individuals each.

The Working Groups were asked to digest and synthesize all of the individual issues that were grouped under their assigned major issue area. Working Groups received their assignments at 8:00 p.m. Saturday evening and continued work through the evening and early Sunday morning. Beginning at 9:00 a.m. on Sunday, the Working Groups presented their reports to all participants. Following each presentation comments were solicited. These comments are printed immediately after each working group report. Before leaving the Conference Center, each Working Group reviewed the text of their report and signed off, approving it for publication.

The "raw material" from which the following ten Working Group Reports were developed is presented in its entirety in Part 2 of this report.

Three Working Groups used PowerPoint presentations. The visuals that they used are reproduced in Appendix E.

PRIORITY 1

Conduct a Timely Initial, but Comprehensive, Assessment to Identify Critical Issues, Data Gaps, and Appropriate Boundaries

WORKING GROUP MEMBERS:

Reynolds, Handley, MacLean, and Weber

Issue Description:

Providing timely initial life cycle evaluations for decision makers is necessary. These evaluations set the stage for early incorporation of the life cycle approach in decision making and identifying realistic options. The initial evaluation will, while creating a foundation for future models, provide policy makers with objective and reliable information upon which to make near-term decisions about public support for alternative fuels and choices of fuel additives.

Transportation fuels are, for the most part, locked into liquid processing and handling infrastructures. All fuels derive directly or indirectly from some natural or anthropogenic energy source material (e.g., coal, crude oil, natural gas, biomass, etc.). Production, and use of different sources, impose different burdens on the environment with respect to energy consumption, pollutant production, and environmental sustainability. Ultimately, since each fuel is to be used in a particular type of propulsion system, the end use of the fuel must be integral to the assessment.

A good analysis will consider a wide range of issues and characteristics, including:

- All life cycle stages (fuel source and production through end use and all associated environmental emissions).
- Direct and indirect impacts.
- Net energy balance.
- Resource use.
- Fuel supply sustainability.
- Multimedia environmental discharges and impacts.

- Economics.
- Consumer acceptance/comparability of fuel/propulsion system alternatives.
- Identification of primary data gaps and uncertainty issues.

As noted, the initial evaluation will focus on a comprehensive structure, not data richness. Emphasis on the structure of the model will ensure that it is comprehensive with respect to incorporating environmental, technical, economic, and societal elements, all of which need to be considered in a meaningful evaluation of alternative fuel (and associated additives) options. It is understood that, in its initial applications, not all of the components of the model can be fully calibrated with available data. This is precisely the point of the model, i.e., to identify appropriate boundaries, data needs, primary uncertainties and priorities for the more indepth analysis to follow.

The outcome of any life-cycle-based analysis is very dependent on the data selected to be used in the models. Nearly all available data are biased, at least to some extent. In addition there are considerable data gaps, particularly as related to environmental discharges and impacts.

Rationale:

The overall goal of informing decision makers requires the development of a robust life cycle model structure. A model, or analysis format, having such a structure will aid policy makers in making more informed and timely decisions. A first-cut assessment will provide foundation information required for the framing and initiation of a more exhaustive approach to overall fuel options analysis.

Most existing models are not comprehensively structured and therefore reflect inherent biases. This has resulted in large disagreements and discrepancies over the outcomes of various studies. The use of such flawed results has, in some cases, resulted in suboptimal decisions being made. The development of the comprehensive framework will provide assistance in accelerating the broad acceptance of a standardized format and the evolution of more precise models.

These evaluations will set the stage for early incorporation of the life cycle approach into compliance models so that the states are properly credited for actions taken.

Proposed Approach(es) to Resolve This Issue:

There are several steps in resolving this issue. First, all available data from existing life cycle assessments (LCAs) and environmental impact assessments should be collected and evaluated for data quality, consistency, assumptions, etc. The industry trade associations and government agencies (e.g., U.S. Department of Energy [USDOE], National Labs, California Air Resources Board [CARB], etc.) could probably fill this role. A central recipient is needed to accumulate,

compile, and catalogue the data. Next, a panel of experts having the greatest cross-disciplinary experience and least possible bias must be established to:

- Determine the core elements to be included in the life cycle modeling approach.
- Review the data and tentatively decide what existing test data and information will be used.
- Identify any data/information gaps and account for related uncertainties.
- Design a preliminary program to fill these gaps.

This panel would then present their findings to all appropriate stakeholders and solicit input. The panel would then finalize the model analysis, properly incorporating any stakeholder input that is based on sound science and with which the panel agrees.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

Appropriate federal government bodies (e.g., USDOE, USEPA, USDOD) commission the National Research Council (NRC) to initiate the activities described above.

Comments:

"This issue complements and supports Priority Issue 9. Both issues stress the need for more standardization in assessig the life cycle impacts of fuels, calling for the development of a robust structure and comprehensive framework. Development and acceptance of such a framework will make life cycle assessments much more useful to all stakeholders. Both issues also stress the importance of data quality and the need to clearly communicate the data and assumptions, as well as the results of the assessment." –***Deborah Adler***

"Issues that I authored (see Priority 1 in Part 2 of this report for full text) and got rolled into Working Group 1 did not make it into the final product. I was not assigned to this working group, but to one that is not germane to my area of expertise. Those who were assigned to the group did not adequately capture the importance of price and supply to the ultimate decision in the selection of alternate fuels." –***Glenn Giacobbe***

"A determination of suitability of the fuel for the intended use should be made. This should include a determination of acceptability by the consumer, including utility as measured by vehicle operability, performance, range, economics, and convenience of re-fueling."
–***John Shipinski***

PRIORITY 2

Fully Identify and Characterize Environmental Release Potential in the Manufacturing, Transport, Storage, and Handling Infrastructure

WORKING GROUP MEMBERS:

Kuhn, Layton, Moller, and White

Issue Description:

A fundamental requirement for a comprehensive life cycle evaluation of the environmental impacts of a fuel is the full identification, characterization, and comparison of the environmental release potentials of its manufacturing, transport, storage, and handling infrastructure (MTSHI). Each step of fuel manufacture, storage, and distribution involves releasing of pollutants into the environment, where they may react and affect air quality or have other impacts. To assess these impacts, it is necessary to quantify and characterize the potential emissions and also identify the individual chemical species involved. The potential releases include accidental, routine, and secondary (i.e., emissions during transportation) sources and causes. An effort should be made to identify data gaps and uncertainties that may need to be further evaluated.

The process starts with an analysis of the differences in infrastructure required to produce and distribute each alternative fuel. The next step would be to conduct a tracking analysis of the fuel through the MTSHI. The process would also identify where releases can be further minimized, or prevented for follow up, should a fuel be adopted for use.

Rationale:

From the point of manufacturing to the point of consumption, it is vitally important to assess the environmental impacts of each alternative fuel on air, water, and waste. A key input to the evaluation of these impacts is the characterization of the releases through the MTSHI of the fuel. Fuel release causes and sources can vary, and may not always be immediately obvious, from fuel to fuel. Identification of the fuels and chemicals released is of primary importance for assessing environmental impacts, particularly for toxics or species whose impacts are due to chemical reactions. Quantification is important for predictive assessments. Both direct and indirect releases are used as inputs to models that simulate the transport and fate of the fuel compounds in environmental media and determine associated human ecological exposures and risks.

One example of the impact of a non-obvious or indirect release is the introduction of significant ethanol quantities to California's gasoline market. Ethanol cannot be blended into gasoline at the refineries and must be transported to the individual distribution terminals throughout the various communities. The result is increased truck traffic through these communities with increased diesel emissions and the potential for highway incidents. The increased potential for accidental releases is applicable to increased delivery miles traveled for both truck and railcar.

Alternative fuels or fuel components will involve different manufacturing processes and may well have substantially varied logistical challenges. An evaluation of fuel alternatives requires the comparison of the release potentials associated with the various changes in the MTSHI. Such issues as materials compatibility, occupational and environmental safety associated with manufacturing and transport methods, and secondary pollution may result in considerable differences from one fuel choice to another.

The release information/data will be used in the actual life cycle analysis, including insertion, as appropriate, into environmental fate and transport, economic, and air quality models.

Examples of factors and circumstances influencing potential releases:

Manufacturing:

- Special risks to workers and the immediate community due to the manufacturing of some fuel components.

- Some alternative fuels require special handling/safety procedures and special training of employees.

- Fuel characteristics will dictate the differences in infrastructure and the potentials for release.

Transportation:

- Increased potential for releases due to mode of transport.

- Increased truck and rail traffic.

- Greater hazard to public via transport corridors.

- Secondary releases caused by mode of transport.

Storage:

- Compatibility of MTSHI system with fuel being stored and handled.

Handling:

- Onsite mixing.
- Special safety precautions.
- Occupational safety and health.

It is important to identify infrastructure weaknesses. It is equally important to address those weaknesses and ensure the identification and quantification of all release sources that are relative to an accurate life cycle analysis.

Proposed Approach(es) to Resolve This Issue:

There are several possible approaches to resolving this issue:

- One approach is to develop a matrix applicable to all alternative fuel options to identify and evaluate both release sources and the MTSHI weaknesses. This would provide a sound basis to contribute needed release information to life cycle analyses intended to compare various alternative fuel options and to expose all environmental risks. Hopefully this approach would better identify and quantify some otherwise unrecognized uncertainties. A matrix approach should consider all potential points of release and acknowledge the unique chemical characteristics of each new fuel. Use of a site conceptual model can be useful in preventing releases and in quantifying releases.

- Compounds that are incompatible with existing storage systems will necessitate special consideration to determine whether different types of storage facilities and/or different tank and piping materials are required. High Reid Vapor Pressure (RVP) fuels with evaporative emissions may require special containment based on the reactivity or toxicity of the compounds present in the vapor. Fuels and the materials used throughout the MTSHI should be tested for compatibility and permeability through a standardized approach that will consider all conceptual points of release in the infrastructure.

- There should be a process to initiate forensic or autopsy-type investigations in the event of a MTSHI failure to ascertain where and why system components are failing. The information gathered from this process will be used to improve the systems relative to pollution prevention.

- Rigorous integrity testing of storage systems, especially underground tank systems, should be required prior to the introduction of new fuels or fuel formulations. The process would also provide a sound basis for further addressing some recognized weak points in the MTSHI. Consideration of pollution prevention in this process can lead to many MTSHI improvements in performance and cost reduction, as well as environmental exposures.

The net product of this process should provide a basis for improved and more focused environmental program enforcement to ensure that all protective measures are in place and maintained in their intended protective modes.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

Those that should carefully evaluate this matter include:

- USEPA
- U.S. Department of Transportation, Office of Pipeline Safety
- U.S. Department of Transportation, Materials Transportation Bureau
- U.S. Coast Guard
- California Environmental Protection Agency (CalEPA)
- National Association of Corrosion Engineers (NACE)
- American Petroleum Institute (API)
- Petroleum Equipment Institute (PEI)
- Steel Tank Institute (STI)
- Fiberglass Tank and Pipe Institute (FGT&PI)
- Western States Petroleum Association (WSPA)

This process must be conducted in an open public forum.

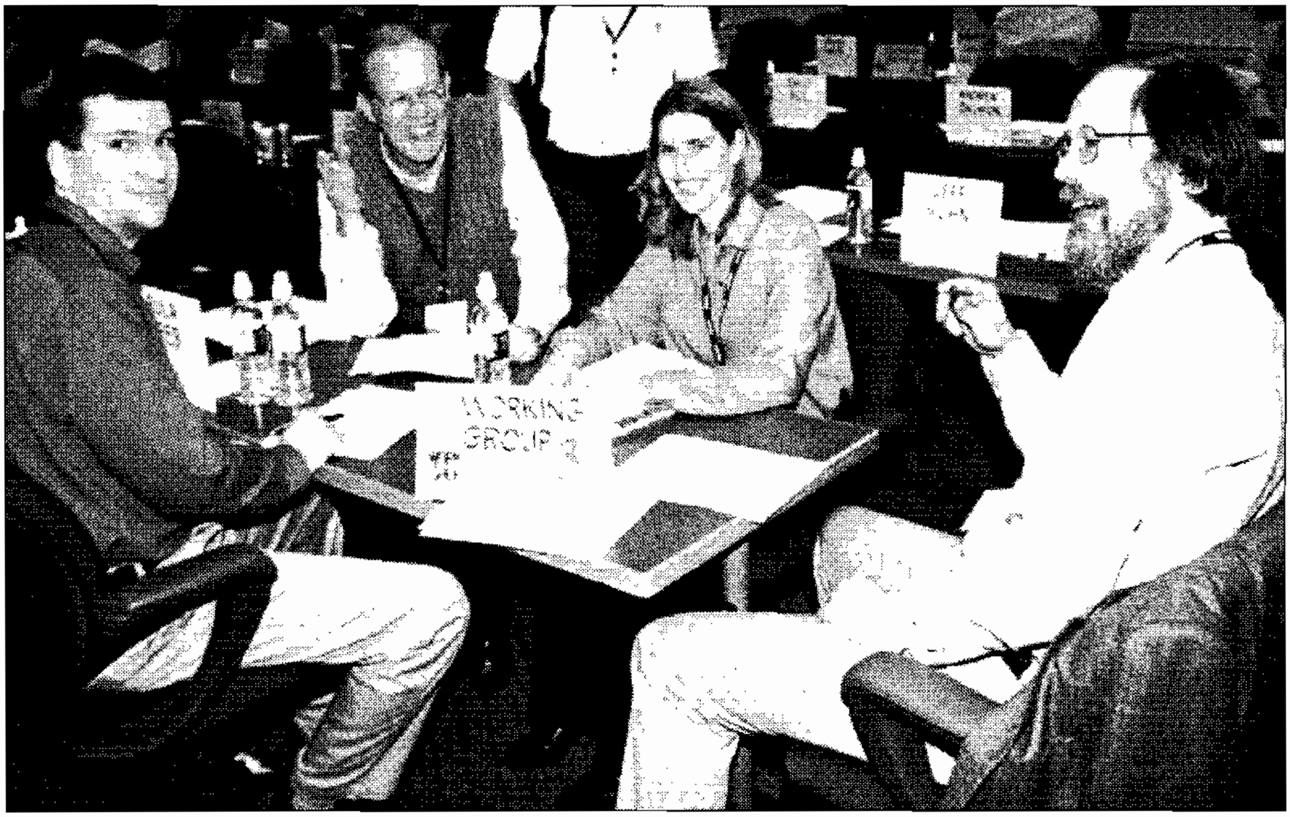
Comments:

"Exhaust emissions obviously also have to be included in identification of 'releases.' No other broad topic covers analysis and speciation of exhaust. Characteristics released should include use of chemical analysis methods to identify and measure chemical species released. Chemical identity may be obvious in case of leaks of whole fuels, but not in cases of exhausts or perhaps. Some process emissions." – ***William P. Carter***

"Review compatibility of systems/infrastructures; also consider the imperfect human factor." – ***James Davidson***

"This issue is too narrowly focused. Release potential begins with feedstock production/recovery and extends through ultimate use and disposal of the fuel and associated byproduct." – ***J. Michael Davis***

"Reevaluation of current compliance standards will be an important part of the retooling process necessary to introduce alternative fuels. Training of state compliance inspectors and stronger regulatory oversight are critical components of leak prevention and will grow in importance as we begin using alternative fuels." – ***Jeffrey Kuhn***


WORKING
GROUP

PRIORITY 3

Application of Human Health and Ecological Risk Assessment Framework to Evaluate the Life Cycle Impacts of Fuel Options

WORKING GROUP MEMBERS:

Davis, Honeycutt, Salmon, and Williams

Issue Description:

The health and ecosystem effects of the chemicals, or stressors, to which populations may be exposed need to be fully characterized as part of a comprehensive assessment of the life cycle impacts of fuels. The risk assessment process consists of qualitative hazard identification, quantitative dose-response analysis, exposure analysis, and the synthesis of the foregoing in an overall risk characterization, which also includes a discussion of the uncertainties in the assessment. It is important to have not only data on the nature of the effect(s) but mode of action as well, where possible. Dose response analysis may take the form of quantitative values such as inhalation reference concentrations, oral reference doses, and cancer potency estimates in the case of human health, or water quality criteria and toxicity reference values in the case of ecological effects. Ultimately, the objective of applying a risk assessment framework is to compare risk characterizations for different fuel options as part of an overall evaluation of their trade-offs (both risks and benefits) in terms of health and ecosystem impacts.

The data to support these risk characterizations should be identified and, where deficient, filled early in the process of conducting a comprehensive assessment of life cycle impacts. Health and ecological risk characterizations are needed for both acute and chronic exposure conditions. The focus should include not only the nominal fuel or fuel additive itself (e.g., combustive and evaporative emissions) but the environmental fate/transport byproducts of the fuel as well as byproduct emissions related to various life cycle stages of each fuel under consideration. Reactive irritants (e.g., aldehydes) in particular warrant attention in a comparative evaluation of new versus existing fuels. Chemicals should be evaluated individually and as mixtures, depending on the nature of potential population exposures and toxicological interactions.

Exposure is part of a causal chain of events starting with environmental releases and leading ultimately to potential impacts on health or ecosystems. At each step of this causal chain, additional variables come into the picture and complicate measurement and assessment, in that measures of environmental quality reflect much more than simply the amount of a release, and measures of exposure reflect much more than simply measures of environmental quality. In

particular, exposure is not simply an inventory of emissions or releases. Rather, it is a complex function of environmental concentration and frequency and duration of contact in relation to various population variables, including activity patterns and demographic and socioeconomic characteristics. For each fuel under consideration, the present and future exposure potential needs to be evaluated for all relevant sources and environmental media to estimate cumulative exposure across routes and for various time periods (e.g., infrequent/accidental acute exposures, daily maximum, and long-term average). As part of an initial exposure analysis, likely microenvironmental scenarios should be evaluated.

Rationale:

The health hazards of any chemical with high toxicity and exposure potential should be evaluated as fully as possible before population exposure occurs. Health hazards need to be understood qualitatively and quantitatively to support risk characterizations and risk-based decision making. Quantitative risk characterization is critical for comparative evaluations of different fuel options, and comparative evaluation is essential to improving the net public health benefits/risks related to real-world fuel usage. It is especially important to examine health risks of new fuels in relation to a baseline of existing fuels. One facet of impact assessment may include identifying differential susceptibility and exposure potential in relation to socioeconomic variables (e.g., Environmental Justice).

Any attempt to understand the possible health and ecological impacts associated with different fuel options should be based on and reflect the potential for both routine and catastrophic exposures. This is important both for risk characterization and for guiding toxicity research strategies. Indeed, the interaction between exposure assessment and toxicity research needs to be iterative if such work is to be done efficiently and effectively. To assess exposure potential, one must also consider various population characteristics, including demographics, activity patterns, and other variables.

Proposed Approach(es) to Resolve This Issue:

This is an iterative process of identifying the fuel, its life cycle releases and byproducts, the potential nature and extent of population exposures, and then conducting the necessary toxicity studies on the chemicals thus identified. Such studies should reflect the exposure conditions of greatest likelihood and concern, e.g., acute high-level for some cases and chronic low-level for others. Depending on the exposure scenario, it may be appropriate to investigate chemicals individually or as mixtures. As health effects data become available, the potency of the chemicals should guide efforts to refine the exposure characterizations for the chemicals of greatest concern. An early start on this process is important to allow time to develop needed data and to provide the opportunity to develop alternative options before major political, financial, and technical commitments are made.

The impact analysis is one of the most important components of the overall decision-making process. Other factors, such as public preferences and values and economic considerations, will ultimately determine how these impacts will be weighed.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

Assessments and evaluations are generally the province of governmental agencies (e.g., USEPA, CalEPA, Agency for Toxic Substance and Disease Registry [ATSDR]), particularly where the derivation of reference values, criteria, standards, or other guidance levels is involved. Formal risk assessments should also be performed by stakeholders and independent parties as part of their own processes of evaluating fuel options. Data generation can be supported by stakeholders (e.g., industry, trade groups), government (e.g., National Institute of Environmental Health Services [NIEHS], USEPA), partnerships and collaborative funding arrangements (e.g., Health Effects Institute), and through academic research initiatives.

Comments:

"I would like to have seen some discussion in this report of the risk of imports to resource beneficial use. In fact, it was the water taste and odor impacts associated with MTBE that was a key factor that led to its ban in California. Further, risk managers do not allow exposure to contaminated drinking water, so the real impact of a toxic material in water is likely the denial of the resource." – ***David Rice***

PRIORITY 4

Net Energy Value of Fuel Options

WORKING GROUP MEMBERS:

Andress, Hodge, Piel, and Powers

Issue Description:

The need for energy is the main reason that many fuel options are being considered. Calculation of the energy required to produce fuels and net energy values (NEV) – energy out minus energy in – are determined by various researchers with inconsistent methodologies and biases. It is imperative that the methodologies be consistent so that the fuel options can be compared. Current differences include:

- Different methods or approaches are used by different investigators.
- Allocation of energy consumption among products, co-products, and byproducts can vary.
- Using high heat value (HHV) versus lower heat value (LHV) can impact the balance.
- The energy value can be impacted by the definition of the system boundaries.
- Impact of recent technology improvements sometimes are not reflected in the energy value.

Rationale:

Government regulators and legislators use the energy values of fuel options to develop energy policies. The NEV is a key indicator of how renewable or economically viable a fuel might be. Various fuel options will require different energy resources that may be of policy concern (e.g., fossil fuel use; petroleum fuel use).

Proposed Approach(es) to Resolve This Issue:

- Energy balance calculation methods, assumptions, and data sources need to be transparent to allow critical comparison among fuel options.

- Depending upon the nature of a particular policy discussion, key energy resources consumed (e.g., petroleum) should be compared among fuel options on a relative basis.
- Use a displacement approach to value the co-products and byproducts.

- Use a LHV for all value comparisons.

- Boundaries must be clearly defined and include all major life cycle components. The energy consumption within the boundary needs to be defined and quantified in reasonably small processing steps (versus lumping many components together). The boundaries need to include the life cycle energy versus the LHV of the energy inputs consumed in producing the fuel option.

- Document details of the technology used and associated assumptions.

- All analysts should attempt to quantify uncertainties in the life cycle data and to reflect these uncertainties in the conclusion.

- At a minimum, petroleum energy should be broken out from other fossil energy consumed in the process.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

There are many people or organizations capable of doing this quality analysis.

Comments:

"I don't think that net energy balance, per se, is of much interest. In the first place, all net energy balances, defined as the energy in the product fuel less <u>all</u> energy inputs in the production of the fuel, are negative, on account of 2nd - law losses. But perhaps more importantly, the 'energy' issue really is a concern about the use of specific commodities, such as imported oil. The use of these commodities in a fuel cycle can't be assessed in a vacuum but must be compared with the use of the commodity in other (baseline, status quo) fuel cycles." – ***Mark Delucchi***

"NEV calculations need to be put into a policy context. There are several questions one needs to ask before carrying on energy-related calculations. First, what issue do I try to address? If one intends to address resource depletion, then NEV can be a valuable exercise. Second, what type of resources am I concerned about regarding resource depletion? If one is concerned about fossil fuel depletion, NEV calculations would be based on fossil fuel use. If one is concerned about petroleum use, NEV calculations would be based on petroleum use. Third, is the fuel evaluated

better or worse than other alternative fuel options regarding resource depletion? NEV shows the result for the fuel evaluated. A broad, and more relevant, question is how the fuel scores relative to other alternatives. A comparison is that, if one has a smaller negative balance in his/her bank account than others, one is in a better financial situation than others, even though everyone has a negative balance in his/her bank account. When comparing different alternative fuel options, it is critical that all options must be evaluated with consistent methodologies and the same system boundaries." – ***Michael Wang***


WORKING
GROUP 5

PRIORITY 5

Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport Characteristics

WORKING GROUP MEMBERS:

Alvarez, Deeb, and Kneiss

Issue Description:

An increase in the demand for alternative fuels will likely increase the use of additives and blending components for different purposes, including production, storage, and use. Potentially problematic compounds include impurities, solvents, corrosion inhibitors, performance enhancers, denaturants, and colorants. In addition, some chemicals may be transformed in the environment into persistent byproducts or into compounds of equal or greater toxicity. While some studies have addressed the potential environmental impacts of selected alternative fuels, there are considerable uncertainties regarding the overall occurrence, fate, and transport of potentially problematic compounds. Specifically, each of the following questions should be addressed:

- Which compounds will be used, where in the life cycle, and at what quantities?
- What do we already know about these compounds, particularly with respect to environmental occurrence, fate and transport?
- Are our current analytical capabilities for detection appropriate, and are they effective at low or trace concentrations in different environmental matrices?
- If these compounds undergo chemical or biological transformations, are there any byproducts of concern?
- How persistent are these compounds and what are their fate and transport characteristics in different environmental media?

- How do multicomponent interactions in mixtures affect the toxicity, biodegradation, mobility, and partitioning of co-occurring and pre-existing contaminants in groundwater plumes?

- What additional information should be collected to predict with a reasonable degree of certainty the behavior of these compounds in the environment?

Rationale:

Identifying potentially problematic compounds associated with the life cycle of alternative fuels and their transformation products is a logical starting point for delineating the scope of screening life cycle assessment. While the above questions are diverse, addressing them is important to identify critical knowledge gaps and prioritize life cycle inventories. Compiling information about pertinent analytical methods and physical-chemical properties that influence the fate and transport characteristics of priority compounds will facilitate proceeding with a meaningful LCA. This information will also be important to identify what additional parameters might have to be included in site characterization and treatment protocols, to identify potential site management complications, and to prevent the duplication of data collection efforts.

Proposed Approach(es) to Resolve This Issue:

White Paper:

A white paper should be produced to forecast the potential demand for components of fuel alternatives and identify likely impurities and transformation products that may adversely impact human health and the environment. In particular, emphasis should be placed on identifying potentially problematic materials and evaluating their likely environmental fate based on known physical-chemical properties, partitioning characteristics, and degradability. Constructing a readily accessible database on these chemicals might also be a good idea. Finally, although not a common part of LCA, the paper should also identify any potentially important externalities and geopolitical concerns when the transfer of raw materials or pollutants occurs across international boundaries.

Environmental Analysis Techniques:

Analytical methods are needed to assess the occurrence of these chemicals in air, soil, and water. It is important that analytical methods are capable of detecting these compounds at low concentrations. User-friendly techniques that are reliable and cost-effective should be considered and widely adopted for use.

Following the identification of target analytes, a range of laboratories, both academic and commercial, can work together with industry and regulatory bodies with input from toxicologists to evaluate the adequacy of current analytical methods and to develop and standardize cost-effective and reliable analytical techniques.

Consideration should also be given to conducting taste and odor studies to determine aesthetic endpoints for those compounds posing the highest risk of impacting water-supply systems.

Persistence, Fate and Transport Studies:

Conduct laboratory experiments (e.g., microcosms, column, and photolysis studies) to characterize the rate and extent of transformation of compounds of interest and the appearance of potentially undesirable byproducts in air, soil, surface water, and groundwater systems. These laboratory studies should be conducted under a range of dissimilar but representative conditions to address response variability as a function of environmental matrix specific conditions. These experiments should provide a basis for screening fate and transport models. Eventually, conduct field studies to characterize the dimensions and stability of the contaminant plumes, verify the laboratory observations, validate the mathematical models, and provide a test bed for novel sampling and analytical techniques.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

A team of multidisciplinary experts, scientists, business leaders, and economists should produce the white paper. Many of the additives that may be important to an LCA could be part of proprietary mixtures; therefore, cooperation with alternative fuel producers will be needed.

For the evaluation and development of novel analytical techniques, a range of laboratories, both academic and commercial, can work together with industry and regulatory bodies to address the development and standardization of cost-effective and reliable analytical techniques and desirable detection limits.

The laboratory fate and transport studies can be performed by either academic institutions or national research centers, and supplemented by consultant and industry support.

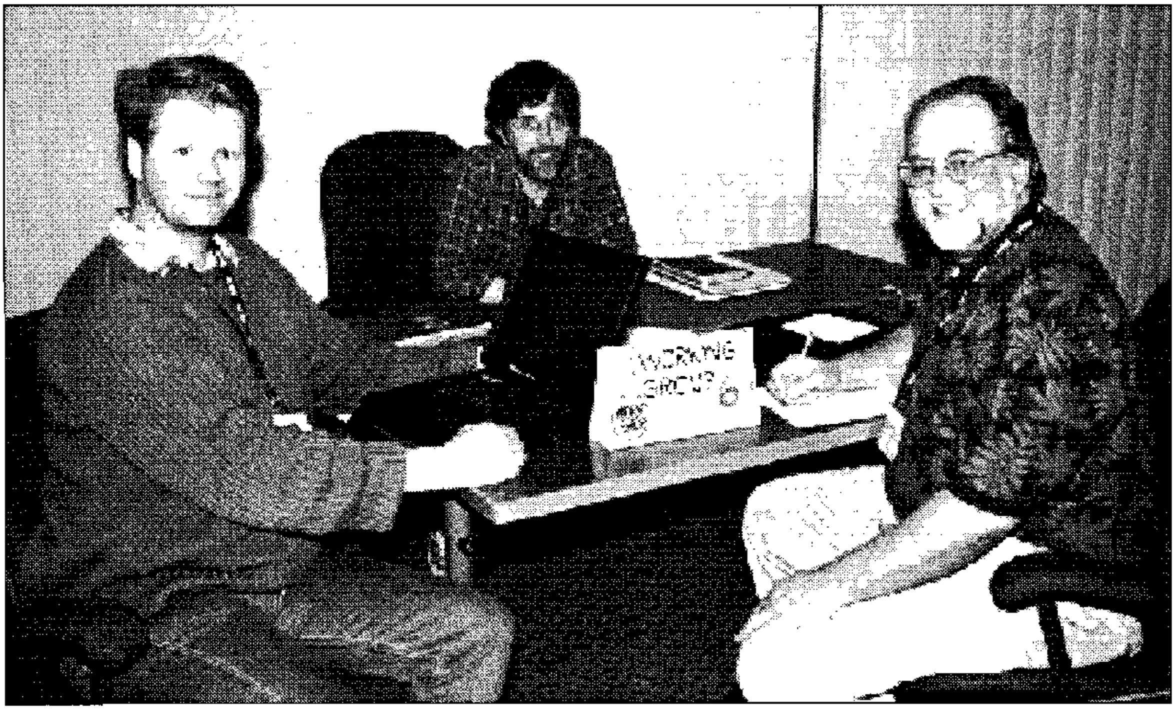
Comments:

"A generally good presentation should have somewhat more emphasis on air impact issues. The topic of air reactivity assessment should be included under this topic. The point of identifying 'problematic' compounds is important and also relevant to air impacts; however, the main (bulk) components are also important and issues of uncertainty in their reactivity and amounts emitted (including variability) also need to be assessed." – ***William Carter***

"This issue should explicitly include air fate and transport and not focus exclusively on water and the subsurface." – ***J. Michael Davis***

"Even if a testing matrix is used to evaluate the environmental impacts of a fuel's life cycle, how do we determine whether those impacts are acceptable or not? What criteria are used to determine unacceptable impacts – or impacts that are very difficult to mitigate?" – ***David Layton***

"Many of the details – lab studies, key chemical parameters, etc. – are written for aqueous systems only. Corollary details for air quality, transformation issues should also be added."
– ***Susan Powers***



PRIORITY 6

Data and Information Systems Need to Be Developed to Support Fuel Life Cycle Environmental Impact Evaluations and Comprehensive Multimedia Models

WORKING GROUP MEMBERS:

Dooher, Rice, and Sheehan

Issue Description:

Data and information systems, including database information models, are needed to support comprehensive cross-media transport modeling and evaluations. In addition to collecting large volumes of data that are needed to feed cross-media transport modeling, such an information system is also needed to collect outputs from various single-media models and to translate and make available these results to other media model components.

Rationale:

Electronic data reporting is becoming more common nationwide. Great amounts of data are available, and scientists performing life cycle evaluations typically spend a significant proportion of their time dealing with data collection. These efforts are often repeated among many researchers.

Advances in information science allow distributed access to databases with different structures, data element names, and units. These advances provide the opportunity to establish an information system that facilitates and streamlines public access and enhances data transparency during life cycle evaluations.

Widespread use of commonly available data is a critical quality assurance step and promotes higher data quality and traceability. An iterative methodology to update poor quality environmental data, as it is viewed and used by those who are closest to it, is essential to keeping high data quality. This iterative process can use the Internet and user-friendly HTML database input systems to avoid the need for database experts for day-to-day operations. These database experts would only be required perhaps on a yearly basis, where they act as facilitators and

coordinators in order to modify the system based on lessons learned by the users in the preceding year. This allows the system to be evergreen.

The use of common data allows calibration and comparative analysis using different life cycle evaluation models. This allows decision makers to understand the differences in models that use the same data inputs.

The unintended water quality impacts of fuel oxygenates that were intended to address air quality problems highlight the need for modeling and analysis that is multimedia in nature – addressing air, water and soil issues. Experts in each area tend to work in isolation with models that are not equipped or intended to talk to each other.

One of the key barriers to doing integrated cross-media modeling is the lack of means for the storage and retrieval of data that supports integrated cross-media modeling. Many models used to evaluate environmental impacts associated with fuel choices are "stove piped." For example, air transport and fate models do not communicate well with water transport models. An information structure is needed to provide the "glue" that allows life cycle evaluation tools and models to communicate and translate inputs and outputs. Once an underlying information model is established, this then becomes the integrating and communications link that enables more integrated multimedia analysis.

Proposed Approach(es) to Resolve This Issue:

The development of an integrated information system to support multimedia environmental evaluations should start with organizations that understand the information needed to conduct life cycle evaluations and that have a series of existing single-media models. Typically, these organizations include multidisciplinary institutions and have models that would form a base set to develop an integrating information system.

A pilot study is needed to demonstrate feasibility of maintaining a "data card catalog" that provides information on where distributed data may be stored. This development of the card catalog would include a comprehensive database of all information that is required by regulatory agencies and development of a good user interface. This database should also include information collected by scientific and research groups, such as USGS, USEPA, and others, and should take advantage of standardization of databases for rapid coordination and integration of information.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

Collaborators for a pilot information system to support life cycle evaluations could be Lawrence Livermore National Laboratory (LLNL), Oak Ridge National Laboratory (ORNL), and National Renewable Energy Laboratory (NREL), USGS, and USEPA.

An example of a database created in such a collaboration is the Geographic Environmental Information Management System (GEIMS) information model, which supports the electronic environmental data reporting required by the State of California, and has been developed based on inputs from the Army Corps of Engineers and LLNL's environmental database modeling system.

Another such model is the USEPA's Air Emissions Database for Utilities (EGRID), which is an excellent method for how information should be pulled together.

Comments:

"The development and maintenance of data and information systems are critical requirements to support Priority 9, Development of a Life Cycle Evaluation and Testing Matrix. The availability of such a comprehensive multimedia database will make life cycle assessment an even more valuable tool for all users. The interconnection and priority of these issues and goals serves to strengthen the need for a more standardized method." – ***Deborah Adler***

"Emissions inventories have hundreds of different chemical compounds, and identifying chemical species is important in data for other media. Current models and databases use inconsistent, incompatible, duplicative, and poorly defined chemical categories. Work is needed so that modeling databases for *all* purposes use consistent and more rational species identifications. Toxics and modeling inventories should be made consistent. I am working on trying to rationalize and make consistent the speciation databases used in air quality models. Whatever is used in lifetime assessment databases should be consistent with this, if possible.

"We should work towards consistent and unified databases that include data used for other model applications and purposes. For example, air quality models used for State Implementation Plans (SIPs) use similar types or input data for some types of life cycle assessments, etc. They should use consistent data to give comparable results." – ***William Carter***

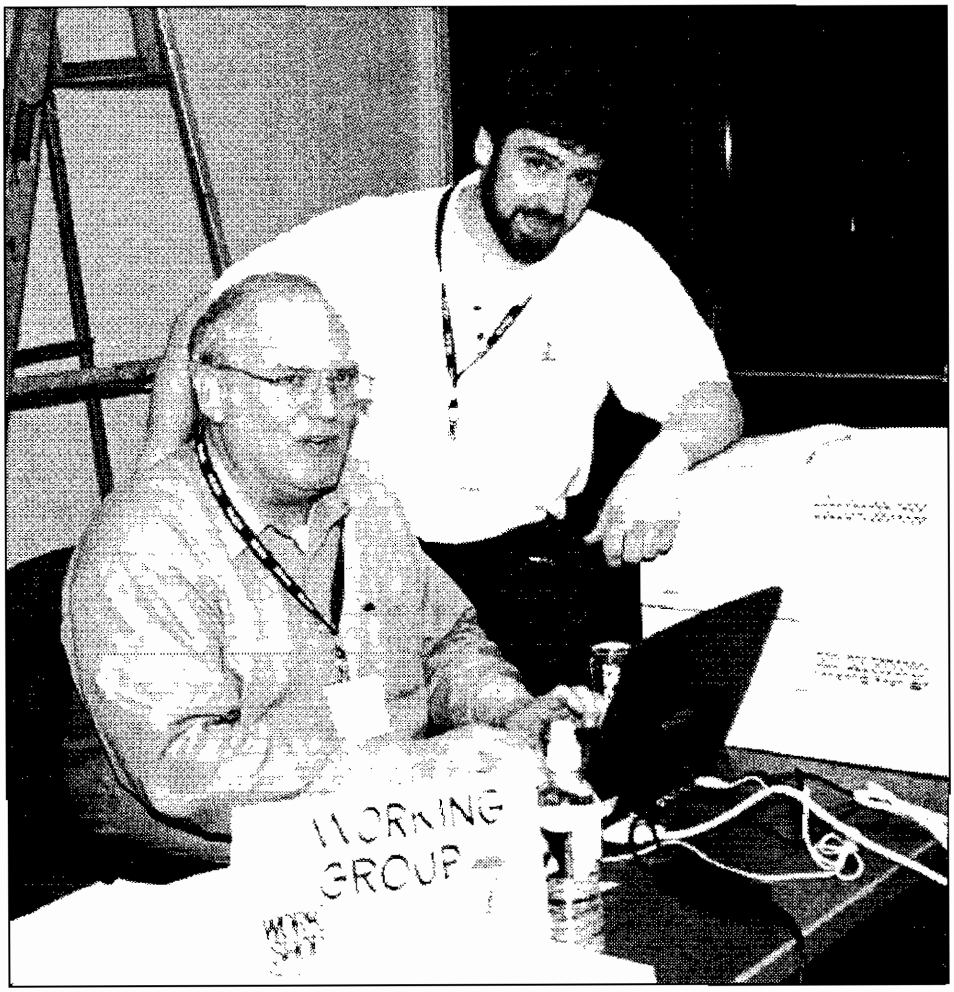
"I fully support the idea of making life cycle release data publicly available through a common database. There are already two similar efforts that I know of: the U.S. Database Project (funded by the NREL) and the Society of Environmental Toxicology and Chemistry/United Nations Environment Programme (SETAC/UNEP) initiative. I suggest recognizing these efforts as possible groups to partner with or support in some way." – ***Mary Ann Curran***

"Complete data sets from state and federal agencies are very scarce. In many cases, the accuracy of the data may also be questionable. Also, there is a very large amount of data (causes of underground storage tank [UST] releases, groundwater cleanup data, etc.) that is present in state files but does not exist in an accessible format that can be processed for trend analysis. These are significant obstacles to policy makers but are important to overcome as part of a complete life cycle analysis." – ***Jeff Kuhn***

"Though it is ideal to have consistent databases to LCAs, this is only true to evaluate the systems already in operation; that is, for existing facilities. It is ideal to maintain consistent databases for

LCA applications; however, when evaluating new technologies for future use, which is the use for many new transportation fuels, no operational data is available for such fuels. In this case, much effort must be spent to collect fundamental data and to make sense of data and scientific judgments to create data for one's analysis. In fact, data collection, processing, and generation have become a significant part of LCA efforts. Although a central data facility may not be applicable for new fuels, researchers need to present the process and results of data collection in a transparent way, so that others can check and modify in their own LCAs." – ***Michael Wang***

"In your approach, have you considered a distinct task that entails 'clean-up' and quality assurance/quality control (QA/QC) of the data? If not, this is an extremely important issue that must be addressed, particularly in regards to drinking-water monitoring data. The California Department of Health Services (CDHS) monitoring database, for example, has numerous miscodings, errors, and omissions, thereby requiring significant effort on behalf of the users of the data to make assumptions about data cleaning/coding, etc. Differences in how researchers deal with these errors can result in widely different analytical results, even though they are using a 'common' database." – ***Pamela Williams***



PRIORITY 7

Improve Communication between Scientists and Stakeholders throughout the Life Cycle Assessment Process

WORKING GROUP MEMBERS:

Davidson, Durkee, and Shipinski

Issue Description:

Because of poor communication between scientists and the other stakeholders (e.g., policy makers, regulators, the public) regarding comprehensive assessments (e.g., LCAs), there is often confusion and/or unrealistic expectations.

Rationale:

If there is a lack of communication, the need for a comprehensive assessment may not be recognized or accepted. If LCAs are conducted, but with insufficient communication between the scientists conducting a study and the nonscientist, then many errors may result:

- The policy makers, regulators, or the public can be confused or misled by inaccurate media reporting and/or political pressures.
- The study might not address the issues that nonscientist stakeholders want addressed.
- The results may not be in a format useful or understandable to nonscientists.
- The assumptions, analyses, findings, and limitations of the LCA may be misunderstood, misapplied, or ignored.
- Valuable time, labor, and money can be wasted.

Proposed Approach(es) to Resolve This Issue:

Establish continuous two-way communication between the scientists and policy makers, regulators, and the public to avoid the above-listed pitfalls. To do this, open communications are needed before, during, and after the LCA process. Specifically:

Before:

- Find out what the policy makers, regulators, and public need to know.
- Effectively explain the benefits of a comprehensive assessment (e.g., LCA).
- Explain the time and resources necessary to conduct a thorough LCA.
- Establish with the stakeholders what the LCA will cover.

During:

- Advise the stakeholders regarding the progress being made.
- Notify the stakeholders if any critical issues arise during the LCA (e.g., the key fuel, component, or byproduct is incapable of being degraded or destroyed).

After:

- Produce a report that fully explains the LCA process used in the study, including assumptions, methods, data sources, uncertainties, and results (i.e., make the report transparent).
- Ensure that feedback from the peer-review process is used to enhance the report's clarity.
- Provide a summary of the assumptions, methods, uncertainties, and results in a format and language that is understandable and useable to the policy makers, regulators, and public (i.e., summarize the report in plain English).
- Make the findings accessible in varied and convenient formats (web pages, press releases, booklets, library copies).

Education:

Providing the various stakeholders a better understanding of the LCA process, and what it can achieve, would help avoid confusion and unrealistic expectations regarding the final LCA report, its uncertainties, and the time needed to complete an LCA. Therefore, it is recommended that a multi-point education program be implemented as follows:

- Create web pages explaining what an LCA is, the terminology used, data required, models utilized, etc. These web pages can be designed to educate policy makers, regulators, the public, and students. Example: www.epa.gov/ORD/NRMRL/lcaccess .

- Prepare educational packets about LCAs for the school systems (junior high school, high school, college) as part of long-tem education.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

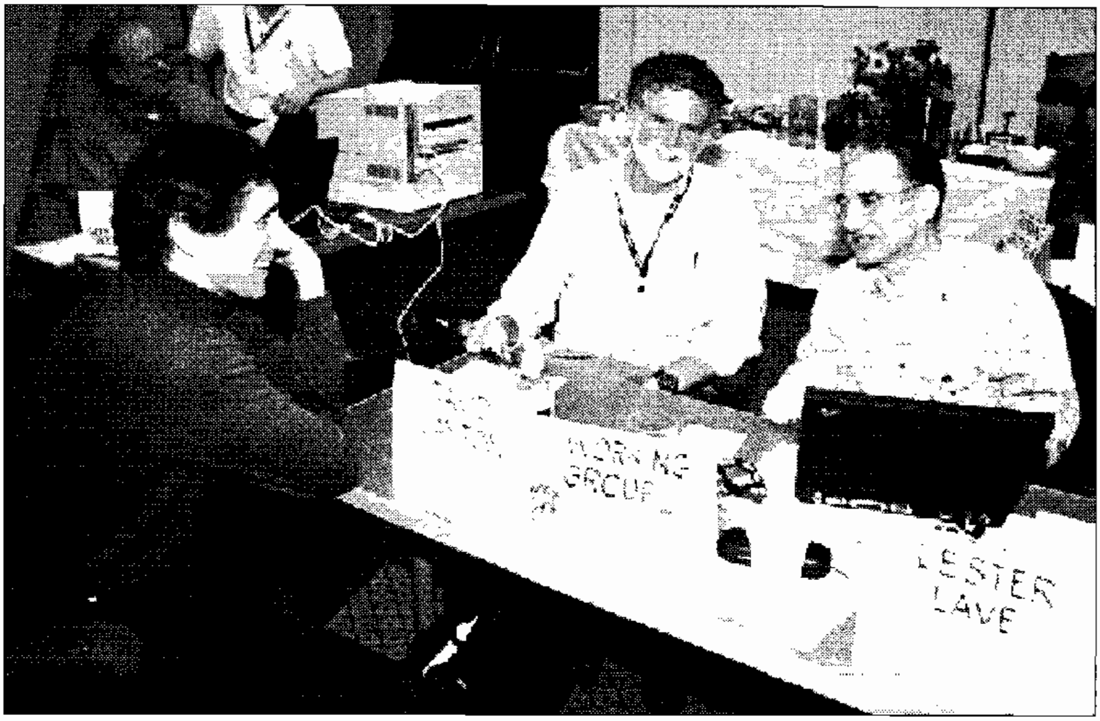
This broad-scale issue cannot be addressed by a single individual or organization. Improved communications require the scientists and numerous stakeholders involved in an LCA all seek to, promote, and encourage open communications at all times.

The educational packets and web pages can be prepared by various federal agencies, state agencies, and private industries. A partnership of these organizations might be the most effective approach.

Comments:

"Some of the discussions about communication with the general public appeared to imply that only very simplified material ('9th grade') is important. This seriously underestimates the needs of the public as well as implying a demeaning attitude on the part of the so-called 'experts.' It is obvious that entry-level material is needed and accessible to people with limited education or interest in the topic. (Provision of this in languages other than English would be an advantage. Was this considered in the full analysis?). But significant segments of the general public, and important special interest groups, also require access to high-level documentation including both analysis and new data. It is important to add this requirement as well and to provide it by affordable and readily accessible means (websites are good!). Communications need to be careful not to underestimate the sophistication and level of interest in some sectors of the general public." ***–Andrew Salmon***

"Better communication is not just a function of finding the 'best way' to present information, data, ideas, etc. It needs to incorporate knowledge about what receivers of that information (e.g., public, policy makers, etc.) want to know. Not only will this result in a more receptive audience, but it may also highlight areas that have been neglected in the analysis because it was not deemed to be important by the researcher(s), but may be valued highly by others."
– Pamela Williams


WORKING
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PRIORITY 8

Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis

WORKING GROUP MEMBERS:

Carter, Delucchi, and Lave

Issue Description:

A limited or misconceived representation of the automobile fuel and life cycle can be misleading. In principle, the analysis should be as comprehensive as possible in three respects:

- Scope (how many indirect effects or links are included?).
- Detail (how much specificity of individual processes?).
- Dynamics (adjustment to changing technologies and prices).

However, it is difficult to model a system in detail in all three respects. This gives rise to the practical issue: in what ways should we compromise the ideal model?

Importance:

The effects that are excluded in a limited or misconceived analysis are potentially important.

For example, battery powered cars have no tailpipe and so no vehicle emissions. However, generating the electricity to recharge the batteries and producing and recycling the batteries can generate large amounts of toxic discharges. The analysis must consider extraction of the lead ore, smelting it, making the batteries, and recycling them. The same is true for other batteries, e.g. nickel, and cadmium.

A second example concerns the behavioral reaction to higher prices associated with more environmentally satisfactory products. An analysis that simply compares a mile of travel in an electric vehicle with a mile of travel in a gasoline internal combustion engine will find lower

emissions in the electric vehicle. However, this comparison may not reflect anything pertinent to a particular policy. It does not consider manufacturer and consumer responses to policies mandating production of a fixed number of electric vehicles. Those responses could result in a product pricing and consumer choices that have perverse effects, i.e., the retention of dirtier gasoline vehicles longer than would have been true in the absence of policy.

A third example. Focusing on reactivity coefficients in vehicle exhausts without considering the refining effects of changing the output of various fuel components can end up harming overall environmental quality. Refiners must optimize cost reduction revenue increases in each market-supply situation, and when they do this in response to new fuel formulation requirements, refinery emissions may change for the worse.

Finally, this problem (of overlooking important economic/sectoral effects) also arises in what often is called "allocation of effects across co-products." For example, most life cycle analyses of petroleum fuels estimate emissions from petroleum refineries and then "allocate" them to specific products of the refinery. But this is not the correct way to approach the problem. The correct way is to analyze what happens to demand for a production of the entire range of petroleum products given a policy affecting directly any one product. To do this, you need to know what policy you are analyzing, and you need to have the tools – economic tools – appropriate to the analysis.

Proposed Approach(es) to Resolve This Issue:

Again, in principle, one should include all sectors that are relevant to the fuel cycle policy, in any way, directly and indirectly. One also needs process-specific representations for the relevant processes, in order to properly characterize environmental impact differences among fuel cycles that differ technologically at the detailed process level. Finally, we need to have the processes, including inputs and outputs, be dynamic; that is, we should represent changes in technology, price, supply, and demand because ultimately changes in supply and demand result in changes in emissions.

The total package is beyond the current scope of knowledge. Technology, prices, and facilities change rapidly over time, making it impossible to set out specific mathematical representations of the optimal processes. We therefore are forced to use more generic representations, which inevitably lose some potentially important distinguishing details. General equilibrium models can represent dynamic economic relationships, but pose specific difficulties of their own, and may be hard to integrate with engineering/environmental models.

Since we cannot do everything we desire, we have to set priorities among more detailed process relationships, broader sectoral scope (or systems boundary), and more extensive and sophisticated dynamic relationships. In this respect, a general methodological question that we face is: Should we start with economic models and import engineering and environmental information, or start with process models and add economic relationships?

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

- Input-output modelers: Karen Polenski (MIT), Rensselaer Polytechnic Institute (RPI), Lester Lave (Carnegie Mellon University), Arpad Horvath (U.C. Berkeley)

- Mixed engineering/economic modelers: Mark Delucchi (U.C. Davis), Paul Leiby (ORNL), Jonathan Rubin (University of Maine)

- Computable General Equilibrium modelers: Larry Goulder (Stanford University)


WORKING
GROUP 9
WORK SHOP

PRIORITY 9

Develop a Life Cycle Evaluation and Testing Matrix for Conducting Consistent Assessments of Transportation Fuel Options

WORKING GROUP MEMBERS:

Adler, Curran, Drogos, and Smith

Issue Description:

Today, we are facing a transportation future with a great many potential fuel options. Due to a lack of sufficient data, it is not appropriate for decisions makers to select a "winner" at this time; therefore, we need to develop and promote sound evaluation tools, such as using life cycle evaluations.

Life cycle evaluations can be used as a standardized, systematic approach for evaluating transportation fuel options. This approach would specify the essential elements that would need to be considered when new fuel options are proposed.

The life cycle evaluation process includes the overarching components of a "traditional" LCA, and also includes cost and societal values, as well as other environmental elements. The matrix would require a consideration of all aspects in the life cycle of a fuel or fuel component, including, but not limited to:

- The availability of the raw materials needed to create the fuel and fuel components.
- The production, distribution, and storage infrastructure needed.
- Physical property data.
- An evaluation of a compound's fate and transport in environmental media (air, water, soil/sediment).
- Human health effects.
- Ecological effects.

- Engine combustion products.
- Costs of production.

Studies that are called life cycle evaluations, but do not include all the life cycle stages or data that do not consider all media (air, water, solid waste, soil/sediment), only give part of the story.

Rational:

A testing and analysis matrix (standardized checklist) that is applied consistently is needed to objectively evaluate future fuels and fuel components. We have learned a great deal from the problems associated with the addition of oxygenates to fuel and need to apply what we have learned to identify potential environmental concerns with new fuel options. Also, it is important to fully evaluate trade-offs that will occur when changing or selecting one fuel option over another.

When faced with so many fuel options, a sound and consistent evaluation is the best method for making the best choices. The development of regional "boutique fuels" and state by state fuel options is symptomatic of the problem of this inconsistency. An evaluation matrix could support new policy development and provide guidance for regulatory decision making. The laws and regulations do not account for cross-media impacts, and the life cycle approach is one way to address the current "stove-pipe" (linear, medium-specific) structure of the regulatory process.

Proposed Approach(es) to Resolve This Issue:

- Develop a life cycle evaluation framework.
- Prepare a checklist of life cycle impacts that must be evaluated for each fuel option.

The following elements provide the framework to guide the analysis, once the data are available. The classic elements of an LCA will be included in the standardized matrix: Raw Material Acquisition, Fuel Production, and Fuel Use. Note that in this application disposal is not a component of the LCA because the product is assumed to consumed in the Use Phase.

These are the elements we would consider to be important for this type of matrix:

- Acquisition of raw materials.
- Availability of the raw materials needed.
- The production, distribution, and storage infrastructure.
- Physical property data for the fuels or fuel component.

- An evaluation of a compound's fate and transport in all environmental media (air, water, soil/sediment).
- Water impacts.
- Health effects.
- Ecological effects.
- Engine combustion products.
- Resource depletion.
- Land use impacts.
- Data quality, including availability, uncertainty, and data gaps.

A multidisciplinary team is needed to compile a matrix for life cycle evaluation and testing of fuels. For example, the creation of a National Fuels Task Force that will use as its starting point the recommendations of the Blue Ribbon Panel on MTBE. Include a "stakeholders group" of industry, government, citizens, and other representatives. Also needed is expertise to assist in defining data needs associated with economic considerations and societal values.

Government may require industry to adhere to a much more stringent analysis of new fuel products, which would include the following elements:

- Require that an evaluation of the matrix elements be completed when new fuel options and additives are proposed.
- Require the testing and review of new fuel compounds.
- Evaluate the economic impacts of the compounds, including release to the environment.
- Follow International Standards Organization (ISO) 14040 guidelines on an LCA.
- Use existing Executive Order 13101 to get government agencies to use the results of this matrix to purchase environmentally preferable fuels. The high volume of federal fuel purchases would encourage more comprehensive fuel evaluation and purchasing procedures.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

- Re-convene the Blue Ribbon panel of experts.
- The USEPA is in the best position to provide this framework and matrix. We recommend representatives from the following offices be consulted to develop the matrix: Office of Research and Development (ORD), Office of Air and Radiation (OAR), Office of Solid Waste and Emergency Response (OSWER), Office of Underground Storage Tanks (OUST), Office of Groundwater and Drinking Water (OGWDW), and USEPA Regional Offices.
- It is also very important to include state entities, equivalent to those in the USEPA (i.e., water, air, and UST programs), who would trigger the need for a fuel life cycle evaluation.

- Academic researchers with expertise in environmental issues, economic modeling, and societal values from Carnegie Mellon University, University of Iowa, University of Waterloo, University of California at Davis, University of California at Berkeley, North Carolina State, and University of Washington.
- Industry representatives.
- Society of Environmental Toxicology and Chemistry (SETAC).
- American Center for Life Cycle Assessments.

Comments:

"The criteria and guidelines presented in Priority 8 should be included in any standardized matrix developed for life cycle evaluation. The matrix that is developed should lead to the generation or use of robust economic-engineering models. And these models should be used to evaluate specific fuel policies as advocated in Priority 8. These goals also emphasize the need for life cycle analyses to be comprehensive. This specificity, breadth, and dynamics are critical if an LCA is to become a useful decision-making tool." – ***Deborah Adler***

"Disposal <u>is</u> a relevant aspect to evaluating the life cycle environmental impacts of different fuel options. The production of waste byproducts in the feedstock production and fuel processing stages will generate wastes that must be disposed of. The matrix or checklist should explicitly include human health and ecological impacts." – ***J. Michael Davis***

"Even if a testing matrix is used to evaluate the environmental impacts of a fuel's life cycle, how do we determine whether these impacts are acceptable or not? What criteria are used to determine unacceptable impacts – or impacts that are very difficult to navigate?" – ***David Layton***

PRIORITY 10

Complete Goal and Scope Definition Is Important for Meaningful Life Cycle Assessment Results and Should Be Incorporated with Other Decision-making Tools

WORKING GROUP MEMBERS:

Giacobbe, Skone, and Wang

Issue Description:

Comprehensive evaluations of life cycle impacts, environmental, cost, or others decision-making tools must be consistent, broad, and clearly defined. For example, LCAs that have less well defined goals and scopes lead to poor decisions because of the inability to advise decision makers with respect to their concerns. This issue results from the misrepresentation of the capabilities of an LCA and the inherent limitations in the interpretation of the results.

Rationale:

An LCA is not a stand-alone decision-making tool. The LCA results must be combined with other key decision-making information (e.g., benefit-cost analyses, economic impacts, social considerations, risk analyses, etc.). The system boundaries and assumptions must be kept the same for all decision-making tools to the greatest extent possible. When using different boundaries and assumptions, these need to be explained to the decision maker in a transparent manner.

The strengths and weakness of an LCA should also be communicated to all stakeholders involved, and, most importantly, to the decision maker prior to conducting an LCA.

Proposed Approach(es) to Resolve This Issue:

This issue can be resolved through increased attention to the importance of defining the Goal and Scope of an LCA. The guidelines to be discussed when determining the Goal and Scope should include the following items:

Scope Definition:

- Content – Describe the issues to be addressed, and the desired results to be generated.

- Temporal – Define the time period to be covered by the study. With respect to transportation fuel options, an extended period of time is needed to account for fuel option penetration and wide-scale acceptance.

- Geographic – Local, regional, country (e.g., United States), or global considerations.

Modeling Approaches:

- Technological improvements need to be taken into account for simulating transportation fuels during the analyzed period. Such examples include improvements in process efficiencies, reductions in process emissions, and improvements in fuel supply chain management.

- Sound methodologies (e.g., material balance, energy balance, engineering simulations) need to be applied for accurately estimating environmental releases.

- Appropriate data quality needs to be defined upfront for achieving defined goals and objectives.

System Boundaries:

- Life cycle stages – Raw material acquisition, manufacturing, use/reuse/recycle, and end-of-life/waste disposal.

- Multimedia Releases – All environmental interventions should be accounted for (quantitatively or qualitatively).

- Direct and indirect processes – Those that contribute to the unit process mass and energy balance, that have a significant contribution to one or more impact categories, and/or that have a release or impact of concern.

Selection of Impact Categories of Relevance and Concern:

- Ozone depletion.
- Global warming.
- Ecotoxicity.
- Human particulates.
- Human carcinogenicity.
- Human noncarcinogenicity.
- Acidification.
- Eutrophication.
- Smog formation.
- Resource supply/depletion.
- Land use.
- Water use.

As part of establishing the Goal and Scope of the LCA, it is important to communicate the strengths and weaknesses of an LCA. Decisions made to structure the Goal and Scope of the LCA will directly affect the strengths and weakness of the LCA and the ability to interpret and use the results. There are numerous and varying strengths and weakness depending on how the Goal and Scope is defined. The following are a few general strengths and weaknesses that should be communicated to stakeholders and decision makers.

General Strengths of LCA:

- Develops a systematic evaluation of all the environmental consequences associated with a fuel option.
- Analyzes the environmental trade-offs associated with one or more specific fuel option in relation to stakeholders of concern.
- Quantifies environmental releases to air, water, and land in relation to each life cycle stage and/or major contributing process.

- Assists in identifying significant shifts in environmental impacts between life cycle stages and environmental media.

- Assesses the human and ecological effects of material consumption and environmental releases to the local community, region, and globally.

- Compares the health and ecological impacts between two or more competing fuel options or identify the impacts of a specific fuel option.

- Evaluates opportunities to change a fuel option to reduce the environmental impacts.

- Identifies impacts to one or more specific environmental areas of concern.

General Weaknesses of an LCA:

- Order-of-magnitude uncertainty in results.

- Lack of impact models to account for all known releases.

- Availability of data.

- Time and resources to conduct an LCA are typically greater than other decision-making tools.

Recommended Individuals and Organizations Best Able to Address/Resolve This Issue:

Anyone attempting to develop a comprehensive evaluation of life cycle environmental impacts.

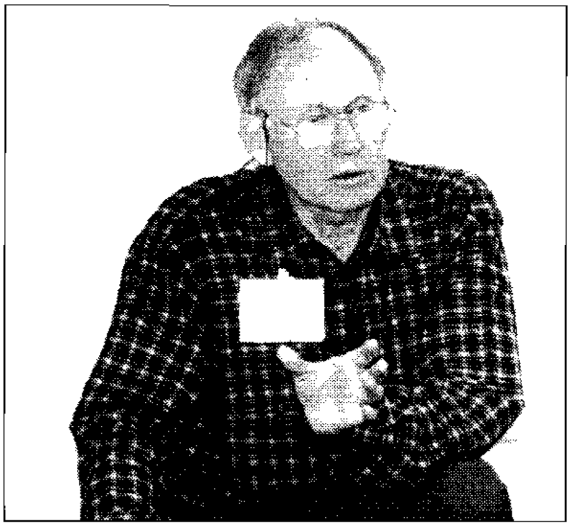
Comments:

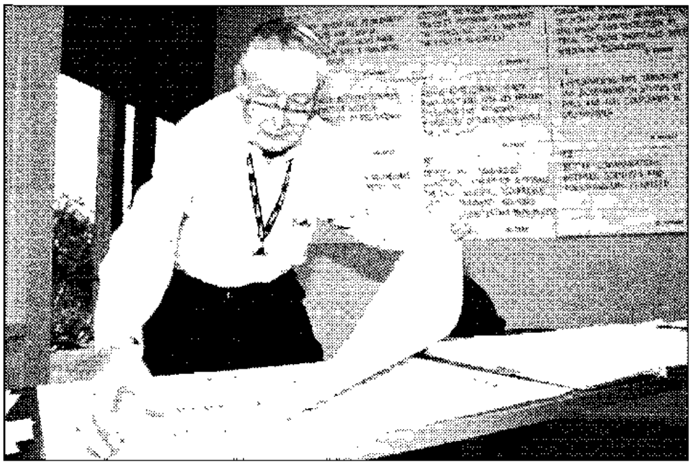
"Defining critical assumptions, as suggested in this working group, is absolutely necessary for transparency. I do not, however, feel that it is sufficient. There are uncertainties in these assumptions. These uncertainties should be used as the basis for a sensitivity analysis to determine if these assumptions have a significant impact on the results of the LCA."
–Susan Powers

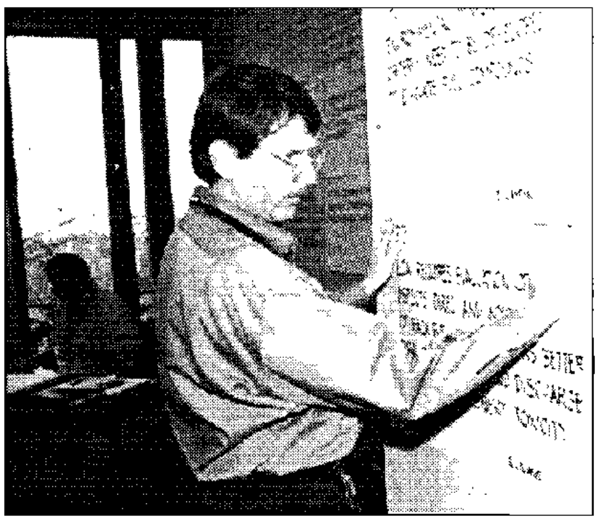
"The chicken-and-egg syndrome must be considered when a new fuel requires changes to the vehicle, as well as significant new infrastructure. The new fuel infrastructure will not be built without the market demand, and the changes to the fleet will not happen without the fuel being in place (witness "Super Quick Charge" for electric vehicles). ***– John Shipinski***

PART 2

NGT WORKSHOP







INTRODUCTION

The Nominal Group Technique (NGT) process was developed by several University of Wisconsin professors, led by Dr. Andre Delbecq, in the late 1960s. The problem they were trying to overcome was the lack of immediate progress when high-level individuals met to resolve an issue. The solution they devised permitted each participant to fully voice his or her views in response to a clearly stated problem without fear of intimidation by other group members. In 1971, Dr. William S. Gaither began using and improving the process while applying it to a wide range of situations. In 1992, the National Water Research Institute invited Dr. Gaither to apply the technique to water-related problems. During the past ten years the NGT process has been continually modified and improved resulting in a wide variety of direct and indirect benefits.

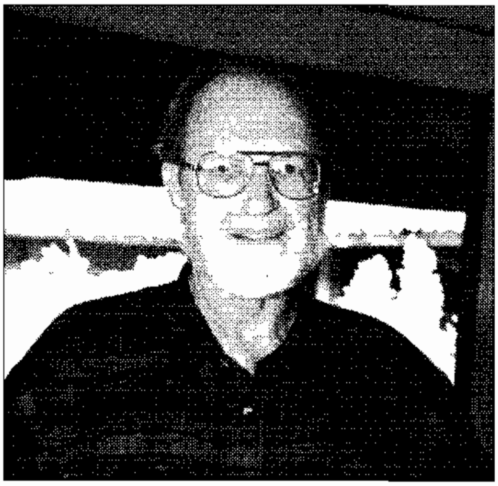
The process is basically very simple. A question for workshop participants to address is designed well in advance of the workshop and is stated in the invitation letter to prospective participants. In the case of this workshop the question was: ***What Are the Most Important Issues That Need to Be Addressed in a Comprehensive Evaluation of Life Cycle Environmental Impacts Associated with Different Fuel Options?*** Accompanying the invitation letter were Workshop Guidelines and Procedures and Issue Identification Forms. The NGT workshop comprises three distinct steps:

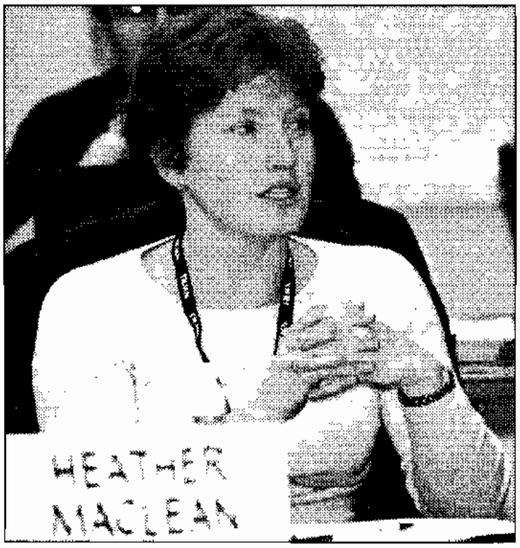
- Identification of issues.

- Consolidation of issues into major issue areas, taking care to avoid overlap between areas.

- Ranking of major issue areas by individual participants.

The 35 participants identified 85 issues during the morning of February 16. Titles of each issue were hand-lettered, numbered, identified by the originator's name, and posted on the workroom wall. After lunch the participants were guided through a systematic process in which the 85 issues were consolidated into 24 major issue areas. At the conclusion of the consolidation step, the participants each ranked their top ten priority issues in descending order of importance. The originating participant signed each Priority Ranking Sheet. The purpose of requiring each ranking sheet to identify its originator was twofold. First, questions about clarity or duplication of selected numbers could be easily clarified, and second, each participant's primary affiliation could be noted so that Strength of Feeling of subgroups of participants could be ascertained.




HEATHER
MACLEAN

PRIORITY 1

Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries

Originators:

Reynolds on behalf of himself, Giacobbe, Handley, Hodge, MacLean, Powers, Rice, Shipinski, and Weber

The following issues were consolidated under the following title:

Title: **Selection Criteria for Data Used in Modeling Life Cycle Environmental Impacts and the Inclusion and Quantification of All Factors**

Originator: Reynolds

Issue Description:

The outcome of any LCA or any work of this type is very dependent on the data selected to be used in the models. Nearly all available data are biased, at least to some extent. Studies by private firms have often been based on premises provided by clients. Studies sponsored by trade associations reflect the interests of their constituency. Government-sponsored projects can sometimes be influenced by legislators. Even academia may be subject to some bias due to funding sources from a specific industry segment. This has resulted in large disagreements over the outcome of various studies, many of which have served as data points in modeling efforts (e.g., USEPA Complex Model versus CARB Predictive model). This has, in some cases, also resulted in failing to include and/or properly quantify all items that impact the environment (e.g., mass emissions versus reactivity adjusted emissions, and how to account for and allocate military impacts on crude oil).

Importance:

If accurate data are not used in developing an LCA and related models, then modeling results will not provide an accurate representation of the full life cycle impacts. Likewise, if factors that impact any area of the environment are omitted, then the model will understate or overstate the total impact of the fuel.

How Do You Propose Addressing This Issue?

There are several steps in resolving this issue. First, all data must be gathered. The industry trade associations and government agencies (USDOE, National Labs, CARB, etc.) could probably fill this role. Next, a panel of experts with the least possible bias needs to:

- Review the data and tentatively decide what existing test data and information will be used.
- Identify any data gaps.
- Design a preliminary program to fill these gaps.

This panel would then present their findings to the various stakeholders and solicit input. The panel would then finalize the above, properly incorporating any stakeholder input that was based on sound science and with which the panel agrees.

Title: **Consumer Acceptance of Alternative Fuels Depends More on Price and Supply and Less on Matters Related to Secondary Life Cycle Issues.**

Originator: Giacobbe

Issue Description:

Replacing MTBE with ethanol or a non-oxygenated fuel will result in higher prices due to reduced supply and higher production costs. For California, the Energy Commission estimates that a ban of MTBE will result in a 5-percent reduction in supply, a 5-cent per gallon increase in cost, and substantially higher pump prices. For the rest of the nation, the U.S. Department of Energy (USDOE) estimates an increase in pump prices of 7 to 8 cents per gallon.

While ethanol is a renewable fuel, the amount of energy that goes into the production of the raw material and subsequent processing is large compared to that of non-renewable options. The energy used to make ethanol is roughly equal to the energy delivered by the fuel. For every gallon of non-oxygenated fuel produced, approximately two gallons of crude oil must be processed. This is an inefficient use of what is ultimately imported: raw material. Crude processing is also energy intensive and a source of pollution.

Importance:

This issue is important because the ultimate goal is to produce transportation fuels with minimal use of non-renewable raw materials and energy. In the case of ethanol and non-oxygenated gasoline, a net increase in petroleum-based raw materials would result. For ethanol, the result is an increase in demand for high-quality components (alkylate) and the rejection of low-quality components (pentane) from the gasoline pool. For non-oxygenated gasoline, the result is an inefficient use of raw material, which is counterproductive toward reducing our dependence on foreign oil.

While MTBE is not a renewable fuel, it is not made from crude oil, either. MTBE is made from alternative energy sources, such as natural gas and natural gas liquids. It does not require the addition of high-value components to the gasoline pool to offset less desirable properties. It does, however, have the ability to upgrade low-value components, and it produces no unwanted byproducts. The net result is more supply.

How Do You Propose Addressing This Issue?

Heed the advice of the USDOE's Policy Office and the California Energy Commission, who have concluded that a ban of MTBE will result in gasoline shortages and very high prices and who have recommended against it.

If water contamination is the problem, then fixing the tanks is the best solution. Properly maintained and monitored tanks are effective in keeping all gasoline components out of water. Recent data suggests that the water issue is not the problem it was once thought to be. Since 1998, the rate of detections has stabilized or dropped, as have concentration levels. These events are concurrent with underground storage tank (UST) repairs.

Until the internal combustion engine can be replaced with fuel cells or truly sustainable fuels, it is in the consumer's best interest to maintain ample supplies of moderately priced fuels until the alternatives mature.

Title: **Resolve Issues Related to the Bulk of the Gasoline Pool and Spend Less Time on the So-called Additives**

Originator: Giacobbe

Issue Description:

Too much of the debate today is focused on 10 percent of the gasoline pool, or the so-called additives. Instead, more focus should be placed on the base gasoline composition, with an emphasis on cleaning it up. An LCA should not consider only future fuels, but a re-engineering of existing fuels or, perhaps, a re-engineering of the refining industry.

Importance:

Close to 50 percent of gasoline today is made up of unsaturated compounds, such as aromatics and olefins (e.g., alkanes/alkenes). These include benzene, toluene, di-cycle butadienes and other multibonded compounds, all of which are responsible for the bulk and toxicity of the emissions.

How Do You Propose Addressing This Issue?

Take this group of people and have them redesign the refining industry to produce clean fuels from petroleum that have minimal environmental impacts and that address issues related to the automobile.

Title: **Two Important Issues That Need to Be Addressed Are Time Frame and Costs**

Originator: Handley

Issue Description:

States are already making decisions about fuels and fuel addictives. Scale-up and infrastructure requirements require maximum lead times. In order for states to choose to remain with or begin using cleaner alternate fuels, an LCA must be completed as soon as possible.

Importance:

If an LCA is to be effective, it must be completed in a time frame that is consistent with the needs of policy makers. In addition, the cost of the LCA must be within the needs of the participants to pay for it.

How Do You Propose Addressing This Issue?

- Contact states to assess their needs for information from an LCA and the deadline for the information.
- Establish a priority needs list that can be accomplished within an available budget.

Title: **High Costs Prevent Alternative Fuels from Being Mainstream Fuels**

Originator: Hodge

Issue Description:

If an alternative fuel does not give the consumer more value than the current mainstream fuel, it will remain an alternative fuel. In evaluating different fuels, we must identify those that have the potential for long-term success. Subsidies should only be given to fuels with the potential to compete successfully when their infrastructure is mature. As an example, consider the MTBE and ethanol pair from a background summary. Ethanol got its first modern boost under Jimmy Carter. At that time, it took more energy to make ethanol that ethanol provided. Ethanol received both a tax subsidy and an environmental subsidy (i.e., a one-psi Reid Vapor Pressure [RVP] waiver). The oxygen standard in the 1990 Clean Air Act Amendments (CAAA90) was intended to create a demand of ethanol. Prior to CAAA90, MTBE was finding its way into gasoline because it lowered the cost of making gasoline. It did this without environmental or monetary subsidy or government mandate. That is why the consumer chose MTBE when oxygenates were mandated. Today, ethanol still needs a subsidy or a mandate to extend its market penetration. The question is will ethanol, methanol, hydrogen, compressed natural gas, liquefied natural gas, propane, wind, solar or "Fuel X" ever be an economic choice? If yes, we should support them through the transition period. If no, we should let our economy be efficient. We should only expend energy and capital on the most economic alternative fuels. Sometimes, that will mean making a cleaner version of what we use today.

Importance:

If we waste our energy and economic capital on the wrong fuel, our economy will be less able to compete in the world market, and our air and water quality will be less than it can be.

How Do You Propose Addressing This Issue?

As a refinery economics engineer, I did mass, energy, and dollar balances to select the best processing options. We must apply the same discipline when we consider different fuels. It would be nice to monetize the environmental impacts as well. But, we must remember the consumer will be guided by Adam Smith's invisible hand. He will not see sunk, soft, imaginary, or environmental costs. He will see costs per mile. Therefore, we must prioritize the work around the fuels that the invisible hand would pick when their infrastructures mature. We can trust the consumer to buy the higher priced, but cleaner fuel, next week.

Title: **"SWOT" the Fuels Early**

Originator: Hodge

Issue Description:

Conventional and alternative fuels have advocates. By nature, advocates are very adept at pointing out and expunding upon strengths and opportunities, but, for balance, someone also has to consider the weakness of a fuel and the threats to its successful or continued use. Such an exercise is called a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. A good SWOT analysis will consider a wide range of issues and characteristics, such as economics, net energy contribution, logistics, politics, sustainability, etc. But, I do not have time to do that right now. So, let us consider how the MTBE example in the background paper would have fared on solubility in water. The fact that MTBE is less soluble in water than ethanol would have been considered to be a strength. MTBE's relatively low solubility provided refiners with an opportunity to replace toxic tetraethyl lead with an octane component that would stay in the gasoline from refiner to end-user. Unlike ethanol, MTBE would not wash out of the gasoline if a storage tank got water in it. If someone had identified MTBE's solubility in water as a threat, it would have been quickly mitigated or downgraded to a weakness when Congress passed legislation requiring that storage tanks not leak. We need to summarize SWOTs associated with each alternative fuel that we consider.

Importance:

An honest SWOT analysis on each alternative fuel considered will make the economy more efficient. It will prevent us from wasting effort on fuels that have threats that cannot be mitigated. It will force us to include mitigation costs in the overall economic evaluation of the alternative fuel.

How Do You Propose Addressing This Issue?

Initially, we would ask a fuel advocate to provide a SWOT analysis on the fuel. When submitting his SWOT, he would be asked to identify and provide SWOTs for competing technologies. Advocates for competing technology would then be asked to provide SWOTs on both their products and their competitors' products. For example, to get the process started, you could ask the Oxygenated Fuels Association to SWOT MTBE and ethanol, while asking the Renewable Fuels Association to SWOT ethanol and MTBE. The Methanol Institute might SWOT methanol, gasoline, and ethanol as fuels for hydrogen fuel cell vehicles, while the American Petroleum Institute SWOTs gasoline, methanol, and ethanol and the Renewable Fuels Association SWOTs ethanol, methanol, and gasoline. An impartial third party could then compile and evaluate the various SWOTs.

Title: **What Would Make the Conventional Fuels and Propulsion System Options Unattractive from the Perspective of Regulators and/or Consumers?**

Originator: MacLean

Issue Description:

Incentives are needed to displace low-priced gasoline/diesel and respective vehicles (attractive options). Current systems are attractive (e.g., price, performance, experience, infrastructure). It is difficult to displace these fuels since there is no vector-dominant alternative. An LCA is a data-, time-, and dollar-intensive process. We need to use our resources wisely and, therefore, focus on the most likely and reasonable alternatives and their evaluation.

Importance:

If alternatives are not accepted by consumers for a large-scale displacement of the status quo, their environmentally friendliness or attractiveness in other ways will not matter. To be successful, an alternative must offer "performance" that is at least equivalent to the current system.

How Do You Propose Addressing This Issue?

- Give greater attention to comparability of options from the points of view of consumers and regulators.
- Conduct broad evaluations of economic, social, environmental, and institutional issues. A realistic evaluation, for example, would not have already decided fuel cells are the winner, and then the analysis would be done to support this.

Title: **Pay Greater Attention to the Comparability of Fuel/Vehicle Propulsion System Alternatives in Life Cycle Evaluations**

Originator: MacLean

Issue Description:

Ultimately, since fuels are to be used in a propulsion system, the end use of the fuel must be included in the LCA. A central focus of the LCA is to provide information to decision makers. When comparing alternative fuels and propulsion systems, we need to make "apples to apples" comparisons. We have to look at the entire system (fuel and vehicle is necessary). There is a

lack of data on many alternatives; these have not been developed to the same extent as conventional fuels and propulsion systems.

Importance:

No two vehicles or fuels are equivalent unless identical. However, comparing options that are not equivalent will lead to misleading results. Many previous studies have compared vehicles with very different ranges, weights, and performance, with little discussion of the impact of these differences on the results. In particular, not taking into account the combination of vehicle and fuel efficiencies has led to misleading results.

How Do You Propose Addressing This Issue?

- Standardize method.
- Incorporate uncertainty and sensitivity components.
- Include technology change, expectations.
- Transparency.

Title: **Reduce the Uncertainty of the Energy Value of Alternative Fuels**

Originator: Powers

Issue Description:

A critical assessment that we have conducted of energy consumption, which is just one component of a fuel life cycle inventory (LCI), illustrates the wide range of values that can be obtained by different researchers. An example is the net energy value (NEV) calculated for corn ethanol. Key issues include the quality and age of data used, boundary choices, and the allocation of some fraction of energy consumed to co-products. Variation in the estimated energy used in production then has a significant impact on associated life cycle emissions and impacts.

Importance:

The range of life cycle results associated with these studies clearly shows that an LCA can be biased, with manipulation in data choices, boundaries, and other assumptions. The energy issue is a critically important first cut in assessing the quality of an alternative fuel, especially if it is to be defined as a "renewable" fuel. The current variability in data, just for corn ethanol, which ranges from approximately –20,000 to +30,000 British thermal unit (Btu) per gallon for corn

ethanol, is used by both proponents and opponents of fuel ethanol to drive policy decisions. Only the NEV is published; details and assumptions are lost.

How Do You Propose Addressing This Issue?

- Need to generate and organize better quality and accessible databases for mass and energy balances. The assumptions associated with all data need to be well documented. Michael Wang's GREET model might be a good place to start.
- Future LCA work needs to strive to be transparent. Data and assumptions used must be clear so biases can be detected.
- LCIs should include sensitivity analysis or other means of quantifying uncertainties.

Title: **Select a Fuel Choice to Demonstrate an Integrated Comprehensive Environmental Impact Process**

Originator: Rice

Issue Description:

Which fuel choice facing the nation would be best to demonstrate a needed comprehensive life cycle approach? Since such an effort would likely take as long as 5 years and cost tens of millions of dollars; near-term fuel choices may not be effectively impacted.

Importance:

To gain acceptance of an integrated systematic approach, we will need to have a timely, added-value benefit to the decision-making process. This may require carefully selecting the future fuel options that are used to demonstrate a life cycle approach.

How Do You Propose Addressing This Issue?

Get feedback from funding sources (e.g., Congress, industry).

Title: **Suitability of the Fuel to the Intended End-use, Including Economic and Consumer Acceptance**

Originator: Shipinski

Issue Description:

Vehicle exhaust and evaporative emissions, operability, performance, range, and convenience of refueling.

Importance:

It is very difficult to get the consumer to pay for less utility (e.g., performance, range, convenience) than she is used to. A fuel that is not used is no alternative at all.

How Do You Propose Addressing This Issue?

Impartial assessment of these issues.

Title: **Tier-One Assessment of All Liquid Fuels, from Energy Source-Depletion/Product-Gain through Final Emissions Analyses**

Originator: Weber

Issue Description:

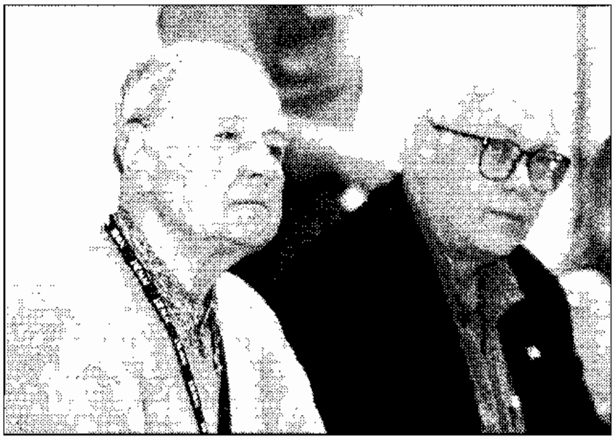
Transportation fuels are, for the most part, locked into liquid processing and handling infrastructures. All liquid fuels derive directly or indirectly from some natural or anthropogenic energy source material (e.g., coal, crude oil, natural gas, biomass, etc.). Net energy potential losses accrue to different candidate fuels (e.g., gasoline, diesel, alcohol, etc.) derived from different candidate energy sources. Production and use of different sources impose different burdens on the environment with respect to energy consumption, pollutant production, and environmental sustainability.

Importance:

This first-cut assessment will provide ground-level information required for the framing and initiation of a more comprehensive, and thus more meaningful, environmental impact analysis. The information may, in fact, guide the selection of optimal types of liquid fuels for a more detailed and comprehensive assessment for specific transportation applications.

How Do You Propose Addressing This Issue?

Much of the information required to carry on this tier-one analysis currently exists, but generally in an unaggregated form. Importantly, that which does not exist will be identified as information needed by the analysis itself. Tier one should be carried out by a cross-disciplinary blue ribbon panel of experts. Is this an NRC job?




ENT FUEL OPTIONS ?"

PRIORITY 2

Fully Identify and Quantify Environmental Release Points in Fuel Transport, Storage, and Handling Infrastructures

Originators:

White on behalf of himself, Carter, Kuhn, Moller, and Williams

The following issues were consolidated under the following title:

Title: **Fully Identify and Quantify Environmental Release Points in the Fuels Transport, Storage, and Handling Infrastructures**

Originator: White

Issue Description:

This issue goes to my experience as manager of ARCO's methanol fuel program back in the late 1980s to the mid-1990s. From the point of manufacturing to the point of consumption, it is vitally important to trace the environmental impacts on air, water, and waste. The points of each potential release of fuel, or associated increased pollution, can vary and not be obvious from fuel to fuel.

One example of this would be the larger introduction of ethanol to California's gasoline market. As ethanol cannot be blended into gasoline at the refineries, the ethanol must be transported to the individual distribution terminals throughout the various communities. This is going to result in increased truck traffic through these communities with increased diesel emissions and potential for highway incidents.

Importance:

The importance of this issue goes to the identification of infrastructure weaknesses aimed at addressing those weaknesses and assuring the identification of all release sources aimed at full quantification of those releases relative to an accurate life cycle analysis.

How Do You Propose Addressing This Issue?

Those best to address this issue are the entities represented in this room.

Title: **There Must Be Adequate Fuel Storage and Handling Laws, Regulations, Standards, and Recommended Practices with Effective Enforcement**

Originator: White

Issue Description:

Any life cycle analysis must begin with a close look at the systems expected to maintain a separation of the fuel from the environment. The issue is so basic. There must be proper fuel storage and handling facility installation and maintenance, as well as equipment integrity and compatibility (including permeability) to ensure durable fuel containment. There must also be effective enforcement agency training, resources, and inspections to ensure compliance. In the event of a release, in the real world, there must also be a means of near-term detection leading to expedited investigation and remedial actions to further minimize impacts for such inevitable, but infrequent, failures.

Importance:

California is a good state to illustrate the importance of this issue. While California had quite adequate UST laws, regulations, standards, and recommended practices in place, its enforcement was absent or ineffectual in many cases. When MTBE was introduced at greater levels in gasoline, there were many substandard UST systems that were not complying with the pre-upgrade leak prevention and detection requirements. Some of the more than 100 UST agencies in California did not have the will and/or resources to properly administer and enforce the UST program. There have been several studies performed in California that point to this lack of enforcement, leading to gasoline- and MTBE-related problems. By the way, the State Water Board has no enforcement authorities under current law.

Presently, California's leaking underground storage tank (LUST) status reflects major improvements since the UST upgrade deadline at the end of 1998. Further improvement will also come from UST program enhancements. Improvements can also be measured by reduced and very low detections of MTBE in California drinking water since 1998. Out of more than 4,000 public drinking-water wells closed due to exceeding maximum contaminant levels, only six were due to MTBE.

It is interesting to note that the European Union has completed MTBE risk assessments that concluded with a competent and enforced European UST programs; risk from gasoline containing MTBE is limited.

How Do You Propose Addressing This Issue?

Those that should carefully evaluate this matter include the USEPA, State Water Resources Control Board (SWRCB), API, PEI, STI, FGT&PI, and WSPA. This process must be conducted in an open public forum.

Title: **There Is Need for Forensics Investigations of Failed Storage and Handling Systems to Ascertain the Cause and Source of Failures**

Originator: White

Issue Description:

There must be a program to investigate and maintain a database on the cause and source of releases from failed storage and handling facilities to ascertain trends related to improper installations, inadequate maintenance, equipment tampering, and faulty equipment. The resulting database should be publicly available.

While there are regulatory and industry specifications with regard to equipment, installation, and maintenance, there is a currently no public process to evaluate whether these programs are adequately ensuring the integrity of the fuel storage and handling systems.

Importance:

Without such an added investigative forensics program to autopsy a failed storage and handling system, there is likely to be:

- Installers that are continually installing systems that may not fully meet regulatory and/or industry requirements.
- A lack of accountability where systems are not undergoing prescribed maintenance.
- Illegal tampering without punitive actions.
- Continued installation of equipment that may be defective.

How Do You Propose Addressing This Issue?

Those best to address this issue include the API and PEI in conjunction with the USEPA and SWRCB. Ultimately, this process must be conducted in an open public forum.

Title: **Identify and Quantify Chemical Species in Emissions or Releases from Production, Storage, Distribution, and Use**

Originator: Carter

Issue Description:

Each step of fuel production, storage, distribution, and use may involve emissions of pollutants into the environment, where they may react and affect air quality or have other impacts. To assess these impacts, it is necessary to quantify both how much the emissions occur, and also identify the individual chemical species involved.

The identification of the type of chemical species must be sufficiently detailed so their impacts can be assessed. For example, the general types of emitted gas-phase chemicals that affect air quality are oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) whose reactions affect formation of ozone and other manifestations of photochemical smog, and individual compounds known to have toxicity concerns, such as benzene and 1,3-butadiene. Different types of VOCs can have significantly different effects on photochemical smog formation when they are emitted, so identifying and quantifying the VOCs components are essential to predicting air quality effects. In addition, it may also be necessary to speciate NO_x in terms of fractions of nitric oxide and nitric dioxide and (possibly) nitrous acid, since these species also have significantly different effects on air quality. Note that highly reactive trace species can have significant effects. For example, trace amounts of nitrous acid in NO_x emissions in exhaust or from other processes may have an effect in enhancing photochemical smog forming processes.

Importance:

Identification is of primary importance for assessing environmental impacts, particularly for toxics or species whose impacts are due to chemical reaction. Quantification is important for predictive assessments.

How Do You Propose Addressing This Issue?

State of-the art analytical methods must be used when monitoring emissions at the source. Steps must be taken to ensure that the analytical and sampling methods are sufficient to detect and quantify all the reactive and toxic species that may be of interest. Steps also must be taken to avoid sampling artifacts and losses. Standard reference methods may not be adequate for all types of species of potential interest. Variabilities of sources, both in terms of amount and speciation, need to be assessed where applicable. In the case of air emissions, environmental chamber experiments can be conducted on direct emissions if there is a concern that highly reactive species are in the emissions that are escaping detection.

Title: **A Life Cycle Assessment Must Consider "Operational Compliance"**

Originator: Kuhn

Issue Description:

- Alternative fuel mixtures may not be compatible with existing storage systems.
- Politics and staff turnovers prevent local agencies from consistently enforcing compliance standards.

Importance:

- We are not doing a good enough job preventing releases.
- State Petroleum Fund Programs are not adequately funded to clean up sites multiple times.
- Businesses do not want to have releases.

How Do You Propose Addressing This Issue?

- Reevaluate current compliance standards for suitability with new fuel mixtures.
- Conduct tank autopsies on all release sites to determine cause. Conoco, Inc. has a standard "causation report."
- Need to move from clean up to compliance.

Title: **Transportation of Transportation Fuels Alternatives**

Originator: Moller

Issue Description:

What changes to distribution and transportation systems will be required? What additional environmental effects will those changes bring?

Importance:

Critical to timeframe, costs, and ultimate net environmental benefit.

How Do You Propose Addressing This Issue?

- Consider the existing transport/distribution infrastructure and the requirements of full alternatives.
- Call upon transportation industry professionals, appropriate federal transport regulators, etc.

Title: **A Life Cycle Assessment Should Not Only Consider the Impacts of Alternative Fuels, but Should Also Consider the Ease in Which These Impacts Can Be Alleviated**

Originator: Williams

Issue Description:

An LCA should identify the sources for various impacts (i.e., sources of environmental releases) and evaluate what is involved with addressing these impacts. If there is an "easy fix" to the problem, then full characterization of the impacts may not be cost effective or necessary – just "fix" the problem. For example, the primary concern with MTBE is drinking-water detections, which is due primarily to LUSTs. While addressing the tank problem may not be cheap or easy, it may be a less costly and more efficient option than trying to address the impacts associated with other alternatives.

Importance:

It is important to incorporate notions of "pollution prevention" in the LCA – perhaps, more so at the beginning of the analysis, rather than in the final "improvement" stage.

How Do You Propose Addressing This Issue?

Perhaps a "modified" LCA framework is needed that would incorporate the notion of source identification and pollution prevention in the initial phases of the analysis – this approach would need to be one that is accepted/adopted by the regulatory agencies.

PRIORITY 3

Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle

Originators:

Davis on behalf of himself, Deeb, Honeycutt, Salmon, and Williams

The following issues were consolidated under the following title:

Title: **Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle**

Originator: Davis

Issue Description:

The health effects of the chemicals to which human populations may be exposed need to be fully characterized. Preferably, these characterizations should be quantitative (e.g., in the form of inhalation reference concentrations, oral reference doses, and cancer potency estimates). Such characterizations are needed for both acute and chronic exposure conditions. The focus should include not only the nominal fuel or fuel additive itself (i.e., combustive and evaporative emissions), but the environmental fate and transport byproducts of the fuel as well as byproduct emissions related to various stages of the fuel life cycle. These chemicals should be evaluated individually and as mixtures, depending on their greatest potential for population exposures.

Importance:

The health hazards of any chemical with high exposure potential (where exposure is a function of concentration, frequency, and duration in relation to various population characteristics) should be evaluated as fully as possible before exposure occurs. Health hazards need to be understood and quantitatively characterized to support risk characterizations and risk-based decision making. Quantitative characterization is critical for comparative evaluations of different fuel options, and comparative evaluation is essential to improving the net public health benefits/risks related to real-world fuel usage. It is especially important to examine the health risks of new fuels in relation to existing fuels.

How Do You Propose Addressing This Issue?

This is an iterative process of identifying the fuel, its life cycle emissions and byproducts, and the potential for population exposures to these emissions and byproducts, and then conducting the necessary toxicity studies on the chemicals thus identified. Such studies should reflect the exposure conditions of greatest likelihood and concern (i.e., acute high-level for some cases and chronic low-level for others). Depending on the exposure scenario, it may be appropriate to investigate chemicals individually or as mixtures. As health effects data become available, the potency of the chemicals should guide efforts to refine the exposure characterizations for the chemicals of greatest concern.

Title: **Preliminary Multimedia, Cumulative Exposure Assessment**

Originator: Davis

Issue Description:

Exposure is more complex than the mere existence of a chemical in the environment. Exposure implies actual contact between an organism and the chemical in question. A preliminary exposure assessment is needed to guide toxicity research and risk management decisions. Such an assessment needs to consider the potential for exposure via all relevant environmental pathways and routes and to estimate the cumulative exposure across routes and for various time periods (e.g., brief acute exposures, daily, and long term) associated with likely microenvironmental exposure scenarios.

Importance:

Without exposure, there can be no effects. Therefore, any attempt to understand the possible health and ecological impacts associated with different fuel options should be based on and reflect the potential for exposure. This is important both for risk characterization and for guiding toxicity research strategies. Indeed, the interaction between exposure assessment and toxicity research needs to be iterative if such work is to be done efficiently and effectively. It is especially important to realize that exposure assessment is much more than emissions data per se. To assess exposure potential, one must also consider various population characteristics, including demographics, activity patterns, and other variables.

How Do You Propose Addressing This Issue?

Emissions data, environmental fate information, and other estimates of environmental concentrations in all relevant media are needed as a starting point. These data are needed for all stages of the life cycle. Microenvironmental exposure scenarios need to be identified. Activity patterns, demographic data, and other information would then be combined with concentration estimates to generate acute and long-term exposure levels.

Title: **Consider Developing Water-quality Standards for Potentially Large Production Volume/Use Chemicals in the Fuel Industry**

Originator: Deeb

Issue Description:

Develop water-quality standards for ethanol, methanol, TBA, MTBE, alkylates, and other additives/impurities in fuels.

Importance:

Much is known about the acute toxicity of most fuel components. It is important to evaluate the health impacts resulting from long-term exposure to low levels of these potential water contaminants. Perhaps any chemical that is produced in large volumes should be considered as a potential emerging water contaminant. If so, should a water-quality standard be developed for these chemicals prior to their use?

How Do You Propose Addressing This Issue?

Most of the compounds of interest here, especially alcohol oxygenates, are not likely to impact drinking water supply wells directly. If they do reach and contaminate water supplies, alcohols are likely to be present at low concentrations. Does this merit going through a process to set a drinking-water standard? Regulators and industry can perhaps work together to resolve this issue.

Title: **Develop Appropriate Acute Toxicity Benchmarks for Risk Analysis**

Originator: Honeycutt

Issue Description:

Current acute toxicity benchmarks (e.g., Acute Emergency Guideline Levels) are primarily geared toward emergency response situations. More subtle effects, such as irritation, exacerbation of preexisting conditions, etc., are not typically considered.

Importance:

Fuel emissions have the potential to cause acute effects that are not typically considered in traditional risk assessments.

How Do You Propose Addressing This Issue?

Conduct research to develop acute toxicity benchmarks (e.g., USEPA, academia).

Title: **Identify Critical Health and Environmental Effect Data and Incorporate Early into Life Cycle Assessments**

Originator: Salmon

Issue Description:

Frequently, when novel technical solutions are proposed, these involve the generation and use of novel chemical products and/or formation of novel byproducts and environmental contaminants. For novel materials or those facing an expansion in the scale or scope of their occurrence, relevant health and environmental data may not be readily available. It is important to obtain these data, whether from existing, but obscure, sources or by *de novo* research. An LCA needs to take account of these data at an early stage, before technical or ideological commitments to specific technical solutions are made without reference to possible impacts on public health and the environment.

Importance:

Unanticipated, undesirable impacts on public health and the environment have followed the introduction of novel technologies without adequate prior evaluation. Data gaps are a frequent problem for risk assessment of novel materials. Too often, health risk assessment is an afterthought to the technical analysis of feasibility and effectiveness of a new technology. This may result in a flawed health and environmental risk analysis due to lack of time to develop the required data. This part of the process may also be perceived as a "spoiler," which is designed to inhibit the ideas of the technical protagonists. The discovery of potential adverse impacts at a late stage may result in a considerable waste of effort and resources and, possibly, attempts to derail the health and environmental assessment process.

How Do You Propose Addressing This Issue?

- Consider possible health and environmental impacts at the earliest stage possible of a novel proposal, and take the opportunity to add value to the proposed alternative by choosing less toxic materials and avoiding contaminating activities.

- Identify materials and address data gaps relating to their environmental safety, which should be monitored following the introduction and use of the new technology (contaminant levels, health impacts?).

Resources include regulatory agencies (CalEPA, USEPA), university research (University of California, University of Southern California), and cooperative and industry sponsored research organizations (Health Effects Institute, Chemical Industries Institute for Toxicology, Lovelace Respiratory Research Institute, individual companies).

Title: **Identify and Characterize the Differential Health and Environmental Impacts to Different Sections of the Community**

Originator: Salmon

Issue Description:

Adverse impacts on health and the environment frequently have the most severe impact on sections of the community (e.g., the poor, minority groups) that do not receive the full range of economic benefits. The analysis of risks and benefits needs to reflect this problem. It is critical to characterize actual data and analysis, not opinion/rumor, etc.

Importance:

If this issue is not addressed, a proposal may be inappropriately selected and, thus, run into major political and social problems down the road.

How Do You Propose Addressing This Issue?

- Recognize the problem. It is not entirely soluble at the technical level.
- Make sure that all the costs are accurately represented and distributed, including costs of remediation to improve environmental justice.
- Regulation of existing solutions to improve cost distribution; avoid perpetuating existing injustices.

Title: **Improved Characterization of the Short- and Long-term Health Effects of Reactive Irritants**

Originator: Salmon

Issue Description:

Many critical air pollutants related to mobile sources are reactive irritants (e.g., peroxyacetyl nitrate, aldehydes, etc.). Many of these are poorly characterized toxicologically, especially with regard to long-term effects (asthma, lung function, cardiovascular disease) and developmental impacts (e.g., children's health).

Importance:

Critical endpoints for current fuels, and many fuel options currently out of the safe zone for many irritants, and total impacts in major urban areas.

How Do You Propose Addressing This Issue?

- Support more research on developmental and long-term effects.
- Look both at individual compounds and combinations/additivity of impacts.

Title: **A Life Cycle Analysis of Alternative Fuels Must Consider Their Relative Environmental and Health Risks and Benefits (i.e., Impact Analysis Is Key!)**

Originator: Williams

Issue Description:

Although selected "pros" and "cons" of alternative fuels have been raised in various settings, there has been littè effort to conduct comprehensive evaluations that take a broader look at the relative environmental and health risks and benefits of these alternatives. For example, much debate has focused on MTBE detections in drinking water, with little regard for whether or not detected concentrations even pose an environmental or health threat. The isolated debate over water quality also ignores the potential air quality benefits of MTBE, and since these latter benefits may more than offset the former risks, the use of MTBE may provide a net benefit to society in terms of human health. Similarly, just because substitutes for MTBE, such as ethanol, may have less impact on drinking-water supplies (in terms of taste and odor), this does not mean that these substitutes will fare better than MTBE on other environmental or health-related

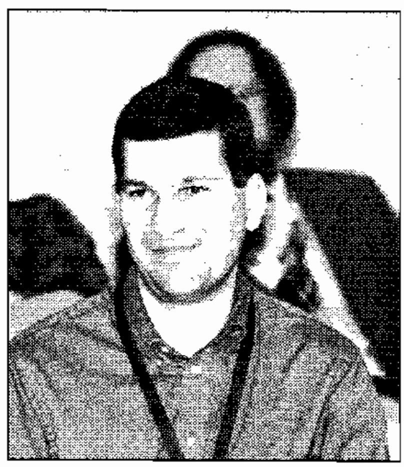
attributes. Ethanol, for example, may require more labor, energy, or costs to produce, may cause more pollution or transport, or may result in greater VOC air emissions than MTBE—all of these outcomes may result in downstream environmental or health impacts. Therefore, a comprehensive evaluation of these types of risks and benefits must move beyond simple "inventory analyses." In other words, not all inputs and outputs associated with an alternative fuel will significantly impact the environment or human health, and some alternatives may have more impacts (i.e., benefits) than others.

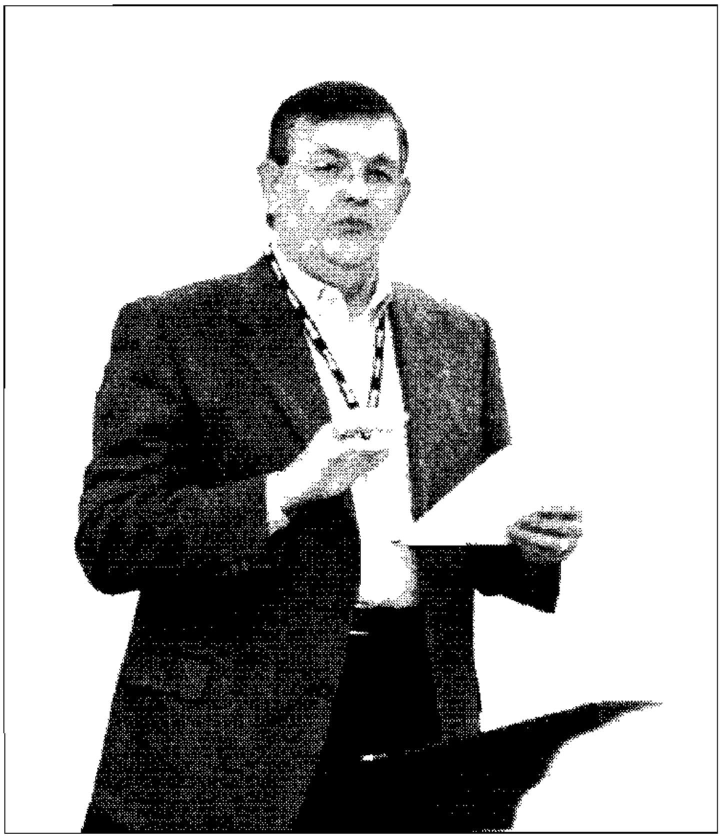
Importance:

The issue of evaluating the relative environmental and health risks and benefits of alternative fuels is one of the most important aspects of a life cycle analysis because it entails quantifying the actual impacts of each alternative. It is not enough to evaluate data on production and use outputs (e.g., environmental emissions to air, water, etc.). These data must be combined with knowledge about human exposures and chemical toxicities to enable meaningful comparisons among these alternatives. For example, if two plants emit the exact same amount of air emissions, one plant may still pose a greater risk to the public than another, depending on its geographical location (e.g., highly urban versus rural area). Similarly, most alternative fuels tend to reduce certain air emissions, while increasing others. It is the amount of these emissions, combined with their relative toxicities, that will determine their net impact on human health and the environment.

How Do You Propose Addressing This Issue?

Perhaps the best way to resolve this issue is to commission a long-term study (2 to 3 years) that would receive periodic peer-review by various experts in the field to objectively evaluate environmental and health risks, benefits, costs, and other life cycle impacts of alternative fuels.





PRIORITY 4

Include Net Energy Balances As a Part of Life Cycle Considerations

Originators:

Hodge on behalf of himself and Powers

The following issues were consolidated under the following title:

Title: **Transforming Existing Fuels into Alternative Fuels May Be a Waste of Energy**

Originator: Hodge

Issue Description:

Are the fuels to be considered actually alternative fuels or are they just old fuels that have been transformed into an alternative form? In the 1960s, millions were spent to convert natural gas to gasoline in South Texas. In the 1970s, utilities converted gasoline to synthetic natural gas. In the 1980s, natural gas to methanol to replace gasoline was in style. In the 1990s, the concept of converting natural gas to gasoline and diesel fuel was resurrected. When will the time be right?

Our poster children for this weekend can be classified as alternative fuels. MTBE is made from natural gas and butane. Ethanol is made from corn and a variety of fossil fuels. Both fuels take products that, either due to physical properties or lack of infrastructure, cannot be used as transportation fuels and transform them into transportation fuels. Is their time up or is it just beginning? Would we be better off to mitigate a water problem or increase the conversion of fossil fuel to renewable fuel? Can we find alternative fuels that both improve the quality of life and are cost effective?

Importance:

This is important because if we use too much energy and/or capital transforming our alternative fuel into a usable form, we will pollute more and not be able to afford to use the fuel. Let us consider our poster children. Ethanol is viewed as a "renewable" fuel. MTBE is not. But, according to a 1995 Department of Agriculture study, it takes one unit of fossil fuel to deliver 1.1 units of "renewable" ethanol energy to the car's fuel tank. Is that enough to pay for the feedstock and infrastructure? Will that decrease the trade deficit? Is ethanol really "renewable"?

Another example: last Sunday, one of the TV news magazines was trying to worry us about our dependence on Saudi Oil. As usual, they oversimplified. But their closing oversimplification disturbed me. Hydrogen appeared to be their solution. If we had hydrogen filling stations, we would all buy hydrogen-powered cars and drive around emitting only water vapor. Now I have not operated a hydrogen plant since 1973. But it takes a lot of equipment, and you have to burn a lot of natural gas to separate the hydrogen from the carbon. The process is also more efficient that using an electric current to make hydrogen from water like we did in high school chemistry. The device that converts the hydrogen to motive power has to be very efficient to offset the energy loss associated with making and delivering hydrogen if the consumer is to choose the fuel and we are to reduce our trade deficit.

How Do You Propose Addressing This Issue?

GM, Argonne National Laboratory, BP, Shell, and Exxon Mobil have done a well-to-wheels analysis that could be a good starting point. It looks at fuel efficiency and greenhouse gas emissions from well to tank...and tank to wheels.

Title: **Reduce the Uncertainty of the Energy Value of Alternative Fuels**

Originator: Powers

Issue Description:

A critical assessment that we have conducted of energy consumption, which is just one component of a fuel life cycle inventory, illustrates the wide range of values that can be obtained by different researchers. An example is the net energy value calculated for corn ethanol. Key issues include the quality and age of data used, boundary choices, and the allocation of some fraction of energy consumed to co-products. Variation in the estimated energy used in production then has a significant impact on associated life cycle emissions and impacts.

Importance:

The range of life cycle results associated with these studies clearly shows that an LCA can be biased, with manipulation in data choices, boundaries, and other assumptions. The energy issue is a critically important first cut in assessing the quality of an alternative fuel, especially if it is to be defined as a "renewable" fuel. The current variability in data, just for corn ethanol, which ranges from approximately –20,000 to +30,000 British thermal unit (Btu) per gallon for corn ethanol, is used by both proponents and opponents of fuel ethanol to drive policy decisions. Only the net energy value is published; details and assumptions are lost.

How Do You Propose Addressing This Issue?

- Need to generate and organize better quality and accessible databases for mass and energy balances. The assumptions associated with all data need to be well documented. Michael Wang's GREET model might be a good place to start.

- Future LCA work needs to strive to be transparent. Data and assumptions used must be clear so biases can be detected.

- LCIs should include sensitivity analysis or other means of quantifying uncertainties.

Title: **Determining the Added Value of Fuel Derived from Waste Materials**

Originator: Powers

Issue Description:

The feed stocks for alternative fuels (methyl alcohol, ethyl alcohol, methane, and hydrogen) can be quite varied, including:

- "Virgin" materials (natural gas).

- Those that could be used beneficially for other uses (corn→food instead of ethanol).

- Waste products (e.g., agriculture or industrial waste→ethanol).

Many current life cycle methods fail to adequately capture the added value of generating fuel from waste materials.

Importance:

The development of waste material feed stocks can help to move towards a true industrial ecology. It is recognized that those sources will not meet national fuel needs, but they could be critically important on regional scales.

How Do You Propose Addressing This Issue?

The best means of conducting an LCA that incorporates the added value of using waste products must be evaluated and implemented. This would necessarily need to include the cost and benefits of externalities not currently considered.




PRIORITY 5

Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport

Originators:

Alvarez on behalf of himself, Deeb, Drogos, and Kneiss

The following issues were consolidated under the following title:

Title: **Identify Potentially Problematic Pollutants and Critical Knowledge Gaps About Their Toxicity, Degradability, Fate, and Transport Characteristics**

Originator: Alvarez

Issue Description:

An increase in the demand for alternative fuels will likely increase the use of additives and chemicals for production, storage, and use. These include solvents, corrosion inhibitors, performance enhancers, denaturants, and colorants; however, there are considerable uncertainties regarding:

- Which compounds will be used, where, and at what quantities?
- What do we already know about these compounds?
- Are our current analytical capabilities for detection appropriate?
- Where will critical materials come from and end up?
- If these compounds undergo chemical or biological transformations, are there any byproducts of concern?

Importance:

This information is critical in order to prioritize life cycle inventories, to discern important environmental interventions, and to identify critical knowledge gaps.

How Do You Propose Addressing This Issue?

A white paper should be produced by a team of scientists, business leaders, and economists that can forecast the demand for such chemicals. Emphasis should be placed in identifying potentially problematic materials and evaluating their likely environmental fate based on known physico-chemical properties, partitioning characteristics, and degradability. Constructing a readily accessible database on these chemicals might also be a good idea. This exercise will identify critical knowledge gaps and prevent the duplication of previous efforts. Finally, although not a common part of life cycle assessment, we should keep in mind externalities and geopolitical concerns when the transfer of raw materials or pollutants occurs across international boundaries.

Title: **Develop and Standardize Analytical Methods to Assess the Environmental Occurrence of Fuel Components, Including Additives, Impurities, and Byproducts**

Originator: Deeb

Issue Description:

Conventional fuel components (e.g., benzene, toluene, ethylbenzene, and xylenes [BTEX]), fuel oxygenates (e.g., MTBE and ethanol), transformation byproducts (e.g., tertiary butyl alcohol [TBA], an MTBE transformation byproduct), and impurities vary with respect to physical and chemical properties and, therefore, analytical techniques. There is a need to develop and standardize analytical methods that can be used to measure a range of these compounds effectively at low or trace concentrations.

Importance:

When ethanol is used as a fuel (95 percent), it has to be denatured. In countries like Brazil, this is typically done with the addition of 5 percent gasoline to lend the fuel a bad taste and odor, thereby discouraging human consumption. Ethanol-blended fuels may have impurities that we are not aware of. TBA, in addition to being a transformation byproduct of MTBE, is often an impurity in MTBE-blended gasoline. Fuel-cell-grade methanol and methanol fuels (used in race cars) have additives, which lend the fuel luminosity (burn with a flame). In many cases, the properties of these additives and impurities are not fully understood.

A critical LCA issue is to be able to evaluate the environmental impacts of these chemicals. To do so, analytical methods are needed to assess the occurrence of these chemicals in air, soil, and water. It is important that analytical methods are capable of detecting these compounds at low concentrations. Finally, user-friendly techniques that are reliable and cost effective should be considered and approved for use.

How Do You Propose Addressing This Issue?

First, additives and impurities have to be identified. Following this, a range of laboratories, both academic and commercial, can work together with industry and regulatory bodies to address the development and standardization of cost-effective and reliable analytical techniques.

Title: **Environmental Fate, Transport, and Biodegradation Studies of Fuels and Fuel Compounds in Groundwater**

Originator: Drogos

Issue Description:

- Conduct studies of the fate, transport, and biodegradability of fuel compounds and fuel formulations in the subsurface environment before they are placed into the fuel supply.

- Evaluate the fate, transport, and biodegradability of the new fuel compounds and fuel formations when commingled with existing contaminant plumes.

- Identify the daughter products of degradation and determine their threats, if any, to the environment.

Importance:

- To identify any potential threats to groundwater posed by new fuel compounds before they are placed into the nation's fuel supplies.

- To identify potential threats to groundwater posed by compound-specific adjustments to fuel formulations. For example, the use of ethanol in fuel required an increase in the amount of alkylates traditionally used in fuel formulations, which necessitated an evaluation of the environmental effects of alkylates in addition to the effects from ethanol.

How Do You Propose Addressing This Issue?

Perform bench-top and field-scale studies at universities or research facilities.

Title: **Health Risk Environmental Exposure and Environmental Fate Data Are Needed before Assessments Can Be Successfully Conducted on Alternative Fuel Components**

Originator: Kneiss

Issue Description:

Health (i.e., toxicological and epidemiological, if available) and environmental testing of chemical products is routinely conducted in advance of their introduction to commence and continues as product markets are developed.

To what point should extensive (and costly) health and environmental testing and comprehensive assessments (based on empirical data rather than simple model predictions) be required of fuel components prior to use (or expanded use) in gasoline?

With the anticipated removal of MTBE from gasoline, data on alternative blending components are lacking to sufficiently assess potential heath and environmental impacts. Regulatory officials need to resist external pressures and factually advise policy makers about the consequences of premature fuel changes in advance of having adequate (comprehensive) datasets on which sound scientific assessments would be made.

Importance:

Do alternative fuel components pose increased risks to health or environment? Do we know all that we need to know about alternative fuel components? Claims of inadequate prior testing of MTBE have resulted in the perception that present concerns about potential health or environmental impacts could have been avoided if all testing was completed first. Considering the lack of information about alternative fuel components, should these alternatives be widely introduced to the gasoline supply before all testing needs and data assessments are completed?

How Do You Propose Addressing This Issue?

Current regulatory requirements under the Clean Air Act, Section 211(b) for fuels and fuel additives testing should be completed, and full regulatory review of testing results should be carried out before fuel policy changes mandated. To fill data-gaps, Toxic Substances Control Act (TSCA) Section 4 actions can be used to ensure that industry fulfills such needs. Both programs are under the authority of the USEPA. Supplemental research programs, such as by the USDOE, USDA, and the USGS can expand the data necessary for sound assessments. Finally, industry needs to adopt progressive responsibility to develop necessary data for these assessments, including voluntary initiatives.

PRIORITY 6

Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models

Originators:

Rice on behalf of himself, Dooher, and Kuhn

The following research issues were consolidated under the following title:

Title: **Data and Information Systems to Support Fuel Life Cycle Environmental Evaluations**

Originator: Rice

Issue Description:

Data and information systems, including database information models, are needed to support comprehensive cross-media transport modeling and evaluations. In addition to collecting large volumes of data that are needed to feed cross-media transport modeling, such an information system is also needed to collect outputs from various single-media models and to translate and make available the results of other media model components.

Importance:

One of the key barriers to doing integrated cross-media modeling is the lack of means for the storage and retrieval of data that supports integrated cross-media modeling. Once an underlying information model is established, this then becomes the integration and communications link that enables more integrated multimedia analysis.

How Do You Propose Addressing This Issue?

The development of an integrated information system to support multimedia environmental evaluations should start with organizations that have a series of existing functional single-media models. Typically, these organizations include multidisciplinary institutions, such as national

laboratories or universities, and have models that would form a base set to develop an integrating information system. Possibly a collaboration between LLNL, ORNL, and NREL could develop a pilot information system. An example of such a database is the GEIMS model, which supports the electronic environmental data reporting required by the State of California.

Also, an agency could assume the role of maintaining a "data card catalog" that provides information on where distributed data may be stored.

Title: **Use Cumulative Knowledge to Inform Decisions: Avoid Infrastructure Development and Destruction by Trying to Know Shortfalls before Introducing New Technologies**

Originator: Dooher

Issue Description:

Building infrastructures is an expensive business and is often pushed by two externalities: consumer demand and regulatory requirements. Sometimes, these are the same; sometimes, they are at odds. A regulatory process that requires large and comprehensive datasets often impedes market forces. Regulatory requirements may be driven by political concerns or real economic need without understanding impacts.

Importance:

Without examining long-term infrastructure trends, the development of any fuel type may end up costing a great deal. Changing political trends can push the development of one fuel type, and then another, resulting in lost economic potential. One example of this was the rise and fall of MTBE, where it was introduced by regulatory fiat, and then pushed out by political and scientific considerations. Another example was the deregulation of electricity in California, where regulatory requirements slowed down the introduction of new generators due to environmental impact requirements, resulting in a backup of capacity and an eventual shortage.

How Do You Propose Addressing This Issue?

Politicians must be well informed, which means that not only industry groups, but also scientists, must be ready to have answers that can be backed up. Industry needs streamlining in the regulatory community so as to quickly introduce needed market requirements. Regulatory agencies often require data that other regulatory agencies collect in order to perform expedited decision making. A comprehensive database of all information that is required by regulatory

agencies should be made available so as to take advantage of the cumulative knowledge. This database should also include information collected by scientific and research groups, (e.g., USGS, National Oceanographic and Atmospheric Administration, USEPA, etc.) and should take advantage of the standardization of databases for rapid coordination and integration of information.

Title: **Need to Develop Complete Data Sets That Lead to an Objective Analysis of the True Impacts of Compounds in the Environment**

Originator: Kuhn

Issue Description:

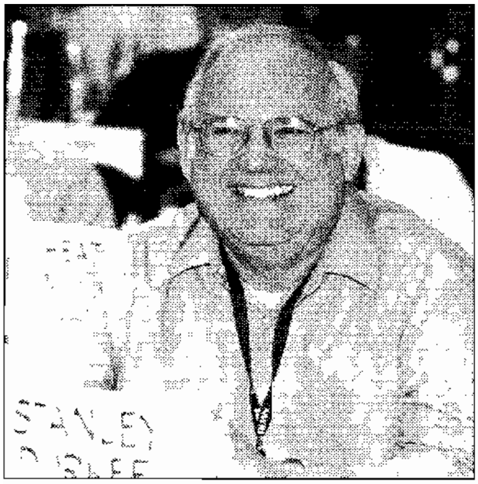
- Difficult to require monitoring for a large number of chemicals constituents–some states are not comprehensively monitoring for MTBE in drinking-water supplies.
- Confusion over which analytical methods to use.
- Costs may be very high.
- Data is "spotty" and difficult to synthesize on a national basis.

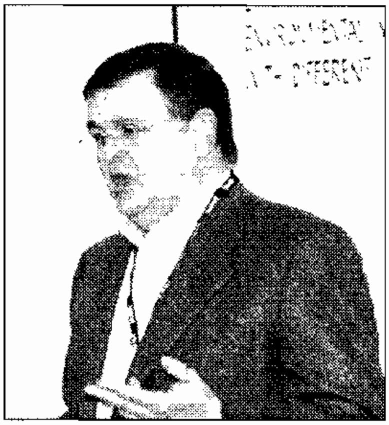
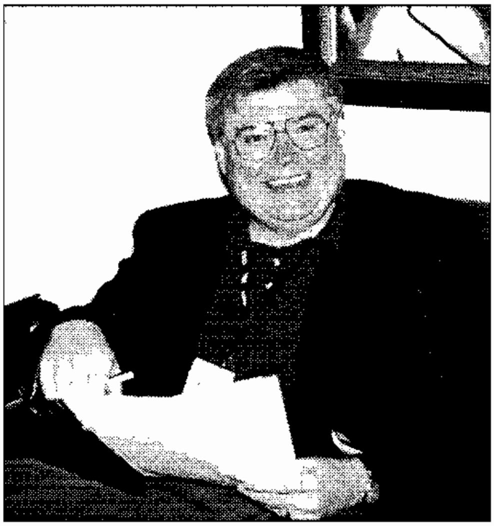
Importance:

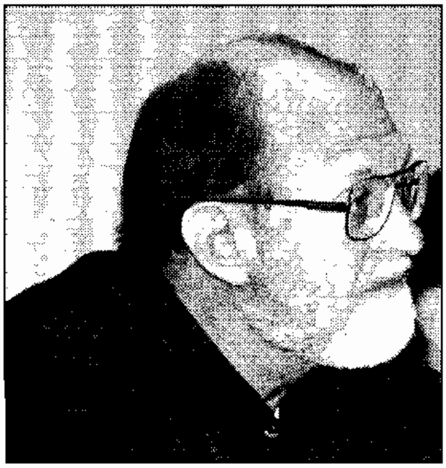
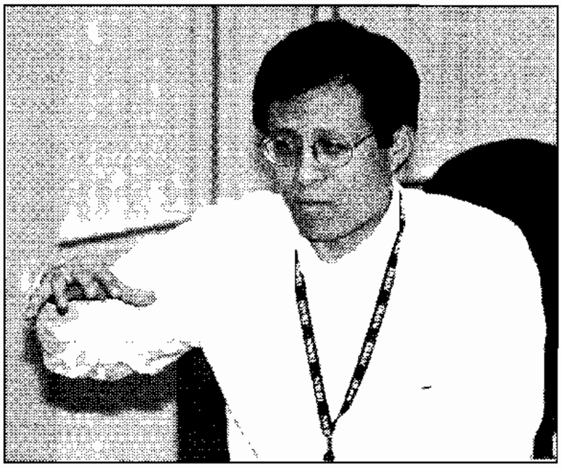
- Cannot easily get a national snapshot of the magnitude of impacts from any single compound.
- Ability of USEPA to gather and use accurate data from states is limited.
- Great amount of data are available but not in a format that can be easily extracted from regulatory agencies.

How Do You Propose Addressing This Issue?

- "If you pay them, they will stay" (keep database workers) - place a greater value on inputting more accurate and complete data.
- Work on creating better data sets; needs to be state and federal priority, so policy makers can draw conclusions from the data and make more informed decisions.



PRIORITY 7

Ensure Better Communications between Scientists and Policy Makers

Originators:

Durkee on behalf of himself Davidson, Handley, Hodge, Honeycutt, Shipinski, and Wang

The following issues were consolidated under the following title:

Title: **Better Communications between Scientists and Policy Makers Are Needed**

Originator: Durkee

Issue Description:

A large barrier to the conduct of comprehensive assessments (loosely defined as multimedia assessments addressing life cycle issues) is the lack of a shared holistic vision. It is not that we do not have tools—we do (e.g., risk assessment, LCAs, etc.). And it is not simply cost considerations (e.g., a screening assessment to identify uncertainties and data gaps can be undertaken relatively inexpensively). It is a lack of "drivers" toward this larger vision.

Importance:

The lack of a shared vision can result in problems of assessment, either in not being undertaken or, if undertaken, with the expectation of potential "rough sailing" for all concerned.

How Do You Propose Addressing This Issue?

- Conduct more workshops, such as this one.
- Encourage everyone to take on a marketing function to encourage the preparation of such assessments.

Title: **Educate Nonscientists Regarding Pros and Cons of Fuel and Fuel Additive Options**

Originator: Davidson

Issue Description:

It can be difficult for the public or legislatures to understand the multimedia science issues and cost-benefit tradeoffs that we make in our fuel options because of the sound bite society in which we live, poor reporting, and stringent advocacy work. With computers, you can readily get any two of three desirable traits – fast, cheap, and reliable – but you cannot have all three desirable traits simultaneously. Similar tradeoff decisions must typically be made with other technology decisions, like fuel types.

Importance:

Simplifying multimedia, multidisciplinary issues will be quite challenging, but we must try to improve the knowledge level of nonscientists (both the public and legislatures). The public and our legislatures need to understand that:

- All our fuel options have some benefits and costs.
- Our job as scientists is to try and optimize costs and benefits.
- There are, as of yet, no magical fuel options (cheap, effective, safe, and no environmental impacts).
- They should avoid falling prey to simplified, sound bite statements.

How Do You Propose Addressing This Issue?

Whatever life cycle analysis methods we use, make sure that the findings and reports are summarized for legislatures and laymen and are actively distributed (via website postings, booklets, executive summaries for legislatures, and "non-executive" summaries for laymen).

Title: **The Presence of MTBE in Groundwater Will Impact a State's Decision-making Process Regarding Participation in the Federal Reformulated Gasoline Program**

Originator: Handley

Issue Description:

The federal reformulated gasoline (RFG) program has made important contributions to improved air quality, and efforts should be made to expand the use of RFG. The presence of MTBE in groundwater may lead states, who can, to opt out of the federal RFG program.

Importance:

States need to be able to quickly, and as accurately as possible, evaluate the full environmental, health, and economic impacts of varying gasoline formulation choices.

How Do You Propose Addressing This Issue?

This should be a collaborative process (inclusive) that includes states, federal regulators, refiners, marketers, and researchers.

Title: **Communication of Life Cycle Assesment Conclusions Is Vital**

Originator: Hodge

Issue Description:

Decision makers must rely on decisions made by life cycle analysts. Consequently, life cycle analysts must be willing to take responsibility for their decisions. They must simplify so that the decision maker can over-simplify. Life cycle analysts must be willing to do the best they can with what they have. If data is truly not adequate, the report must say so.

Importance:

Politicians who make decisions concerning fuel options will not read a 400-page report. Most also will not understand LCA reports. If we do not communicate clearly, politicians will not fund LCAs.

How Do You Propose Addressing This Issue?

Pay low grade-point-average or low-income freshmen to read the report prior to publication, then write a one-page paper about what the report says. Select the freshmen from a variety of majors.

Title: **Public Education of Environmental Risks from Fuels and Fuel Additives**

Originator: Honeycutt

Issue Description:

Often, public education concerning environmental contamination of fuel and fuel additives comes from the press, which can be inaccurate; therefore, when fuel and fuel additives are found in the water, the public is often frightened and distrustful of "the government."

Importance:

Public education of risks can head-off distrust/fear if the public is exposed.

How Do You Propose Addressing This Issue?

- Prepare press packages.
- Develop elementary and high school education curricula.
- Gear information toward audience.

Title: **"Edenic" Expectations of Technology**

Originator: Shipinski

Issue Description:

Nontechnical people (i.e., those who do not grasp the first and second laws of thermodynamics) impute powers of magic to new technology.

Importance:

This leads to political pressure, which in turn leads to a misallocation of resources.

How Do You Propose Addressing This Issue?

I do not know.

Title: **Credible Life Cycle Assessments Need to Be Transparent with Uncertainties Addressed**

Originator: Wang

Issue Description:

LCAs need to be transparent in order to present system boundaries, data sources, and assumptions in a clear way so that readers can understand what is behind the results. LCAs need to address uncertainties in a systematic way. LCA users often expect point-estimate results. But, thc reality is that there are many uncertainties involved in technologies, especially the technologies for the future. On the other hand, results from different studies may show larger uncertainties than they actually are because underlying system boundaries and methodologies are different among studies. The uncertainties induced by different system boundaries and methodologies need to be sorted out and eliminated.

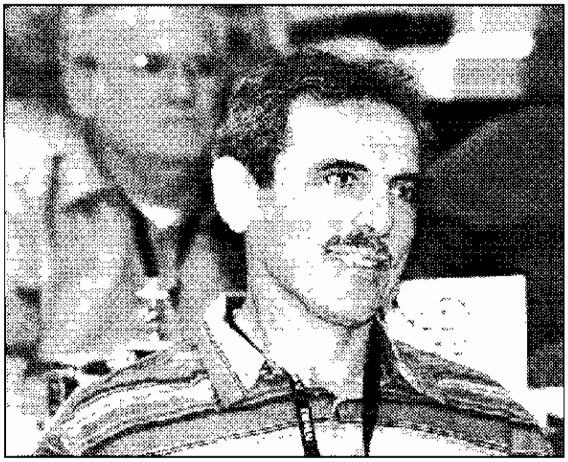
Importance:

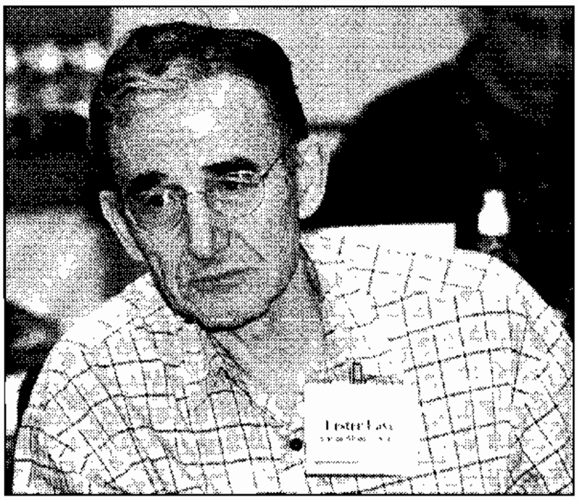
Because of less transparency of studies, LCA users are often confused. Transparency of LCAs will help users better understand the results.

Uncertainties with LCA results are part of the reality. A better way is needed to convene LCA results to policy makers and politicians; however, uncertainties need to be addressed in scientific ways.

How Do You Propose Addressing This Issue?

Good scientific analysis.





PRIORITY 8

Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis

Originators:

Delucchi on behalf of himself, Andress, Dooher, and Lave

The following issues were consolidated under the following title:

Title: **Formulate Specific Fuel Policies, Compare the World with and without the Policy, and Use Economic Engineering Models to Do the Analysis**

Originator: Delucchi

Issue Description/Importance:

The most important issue is to have the right overall method that formulates specific fuel policies, compares the world with and without the policy, and uses economic-engineering models to do the analysis.

In most, but not all, life cycle analyses of transportation fuels, analysts have used engineering models to analyze generic, nonpolicy specific options. This gives rise to problems:

- When the CARB mandated the sale of electric vehicles (EVs) in order to improve air quality, some analysts compared the life cycle emissions of EVs with the life cycle emissions of gasoline vehicles. In essence, they compared emissions from electricity generation associated with X miles of travel by electric vehicles with tailpipe versus upstream emissions from X miles of travel by gasoline vehicles. They found a large reduction in per-mile emissions and thus concluded that the use of EVs would improve air quality.

  But this sort of analysis ignores some key effects of the actual CARB policy—key effects that require economic models as well as engineering models. The CARB mandated the sale of EVs, which are relatively expensive to manufacture. In order to sell enough EVs to meet the mandate, automakers would have had to subsidize EVs and raise costs on the gasoline

vehicles. Although new gasoline vehicles are cleaner than the ones they replace, the net effect would be an increased retention of older, polluting vehicles. The increase in emissions due to the retention of older gasoline vehicles outweighed the reduction in emissions due to the sale of a few EVs, and changed the sign of the results: the EV policy would increase rather than decrease emissions.

Now, we cannot arrive at this arguably more accurate result unless we formulate a specific policy and then use the appropriate models, including economic models, to analyze the policy.

- Another problem also occurs with the "allocation of effects across co-products." For example, most life cycle analyses of petroleum fuels estimate the emissions from petroleum refineries and then "allocate" them to specific products of the refinery. But this is an incorrect way to approach the problem. The correct way would be to analyze what happens to the demand for the production of the entire range of petroleum products given a policy affecting directly any one product. To do this, you need to know what policy you are analyzing, and you need to use the economic appropriate to the analysis.

How Do You Propose Addressing This Issue?

To address this issue, I propose at least modestly increasing the funding given to me and colleagues at ORNL to analyze the issue.

Title: **How Should Economics, Produceability, and Infrastructure Issues Be Incorporated into Environmental Life Cycle Analyses?**

Originator: Andress

Issue Description:

Some life cycle analyses do not explicitly incorporate economic, infrastructure, and produceability considerations and constraints in the analysis.

Importance:

Not bringing these factors in at an early stage can lead to potential price spikes and supply disruptions. Also, cases that will not be realized because these factors may not be considered (e.g., in a Monte Carlo analysis that assigns equal weight to all possibilities) could skew the utility of the analysis.

The NRC report on issues related to ozone and RFG recommended against assigning reactivity and weights to VOC emissions, based on comparison criteria that did not consider the economics

of refining operations; however, some analyses have suggested that the added flexibility would reduce production costs while preserving air quality.

The current situation in California to reassess the MTBE phaseout schedule just months before the ban is scheduled to take effect shows that these factors may have not have been well understood.

How Do You Propose Addressing This Issue?

Bring these considerations into the analysis at a very early stage.

Title: **Opportunity Costs Associated with the Introduction of Various Transport Technologies**

Originator: Dooher

Issue Description:

The recent National Academy of Sciences Corporate Averaged Fuel Economy (CAFÉ) report examined the costs and benefits of requiring automobile manufactures to increase fuel economies. The report did not examine the opportunity costs of forcing a series of new technologies on auto manufacturers before the technologies are ready for mass introduction.

Typically, the most expensive technologies that are the most advantageous from a marketing point of view are introduced first into the most expensive automobiles, and gradually make their way into general lower-cost auto production over time. Forcing such technologies into immediate production on a fleet-wide basis results in extremely high recovery costs for the auto manufacturer and raise costs for the consumer that cannot be recovered through fuel savings. The opportunity costs of introducing these immediately instead of over a long term may even be higher – resulting in less research and development in systems that could prove to be of even greater advantage when the real goals of the program are examined.

Importance:

An LCA can help decision makers set priorities on laws and regulations that they are imposing on the public. The LCA must look at what the opportunity costs are that result from these new requirements, and what the real long-term goals are. If the goal is to reduce fuel usage due to global warming or oil independence, the gains that may occur over an automobile rollover transition time of 15-30 years from increased CAFÉ standards may be less than investing in new technologies and fuels that may accomplish the same or superior goals in approximately the same time frame.

How Do You Propose Addressing This Issue?

Auto manufacturers, fuel producers, distributors, economists, politicians, and scientists should use the LCA process to examine the CAFÉ process in light of the stated goals and the transition times for the fleets, as well as on the realistic estimation of the introduction of new fuel types, technologies, and infrastructure.

Title: **A Life Cycle Assessment Requires Evaluation of All Aspects, Direct and Indirect, of Each Fuel's Life Cycle, As Better Data on Water Use and Discharge, As Well As Component Toxicity**

Originator: Lave

Issue Description:

America's light duty fleet currently uses 130 billion gallons of fuel costing $150 to 200 billion dollars, annually. The associated vehicle equipment associated with each fuel includes heavy metals in batteries, noble metals and polymers in catalysts, and exotic materials in fuel cells. The indirect effects associated with the fuels are at least twice the direct effects, often generating greater environmental discharges than the direct processes themselves.

Importance:

The USEPA-SETAC, life cycle assessment approach requires detailed mass and energy balances, which are expensive and time consuming. As a result, a tight boundary must exclude all but a few of the relevant processes, or data from old analysis, sometimes quite dated, must be used. A hybrid LCA combines detailed mass and energy balances of crucial processes with a full LCA of all indirect effects using economic input-output analysis. This tool is still under development, but the economic input-out, LCA is available on the web atwww.eiolca.net . A hybrid Economic Input-Output LCA is currently being developed under National Science Foundation funding.

How Do You Propose Addressing This Issue?

Crucial data gaps need to be addressed. A primary one is that water use and discharge data have not been collected nationally since 1983. The USEPA's air pollution data, while far from flawless, is far superior to its water pollution data.

A second critical issue is better characterization of the toxicity of components of the fuels and the inputs to the production. A toxicity program needs to set priorities in terms of the quantities of each chemical discharged into the environment, as well as preliminary information on toxicity.

PRIORITY 9

Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options

Originators:

Drogos on behalf of herself, Adler, Curran, and Kuhn

The following issues were consolidated under the following title:

Title: **Develop a Life Cycle Evaluation and Testing Matrix for Transportation Fuel Options**

Originator: Drogos

Issue Description:

Create a standardized systematic approach for evaluating transportation fuel options. The approach would specify the essential elements that would need to be considered when new fuel options are proposed.

The matrix would require considerations of all aspects in the life cycle of a fuel, such as the availability of the raw materials needed to create the fuel and/or fuel component; the production, distribution, and storage infrastructure needed; its physical property data; an evaluation of a compound's fate and transport in all environmental media (e.g., air, water); health effects; engine combustion products; the costs of production, etc.

Importance:

A testing and analysis matrix (essentially a standardized checklist), applied consistently, is needed to objectively evaluate future fuel options. We have learned a great deal from the addition of oxygenates to fuel and need to apply what we have learned to identify potential concerns with new fuel options.

How Do You Propose Addressing This Issue?

- Use a multidisciplinary team to compile a matrix of life cycle evaluation and testing for fuels.
- Require that an evaluation of the matrix elements be completed when new fuel options are proposed to the USEPA.

Title: **Standardize a Life Cycle Fuel Assessment Methodology So That Fuels and Policies Can Quickly and Consistently Be Evaluated**

Originator: Adler

Issue Description:

Right now, we are facing a transportation future with a great many fuel options. It is not appropriate to pick a fuel or vehicle "winner" at this time. Therefore, we need to develop and promote sound evaluation tools, like LCAs.

Importance:

When faced with so many fuel options, a sound and consistent evaluation is the best method for making the best choices.

How Do You Propose Addressing This Issue?

Establish an LCA as a standard assessment tool for fuels, once the appropriate methodology has been developed and endorsed. This may require regulatory action.

Title: **A Comprehensive Life Cycle Evaluation Should Strive to Be Cradle-to-Grave and Cover Multimedia Environmental Impacts**

Originator: Curran

Issue Description:

Studies that are called life cycle evaluations, but do not include all the life cycle stages or all media (e.g., air, water, and solid waste), only give part of the story.

Importance:

It is important to fully evaluate trade-offs that will occur when changing a product system or selecting one over another.

How Do You Propose Addressing This Issue?

Follow ISO 14040 guidelines on LCAs.

Title: **Develop a Process by Which Petroleum Additives Are Evaluated to Determine Their Potential to Create Public Health Effects and Environmental Impacts**

Originator: Kuhn

Issue Description:

What role should the federal and state governments share in this process, and how do we provide assurance to the public now, in the wake of MTBE, that petroleum can be safely stored, and that compliance standards for storage tank systems are adequate? States are very concerned about the adequacy of the current standards and ability of the USEPA to address them.

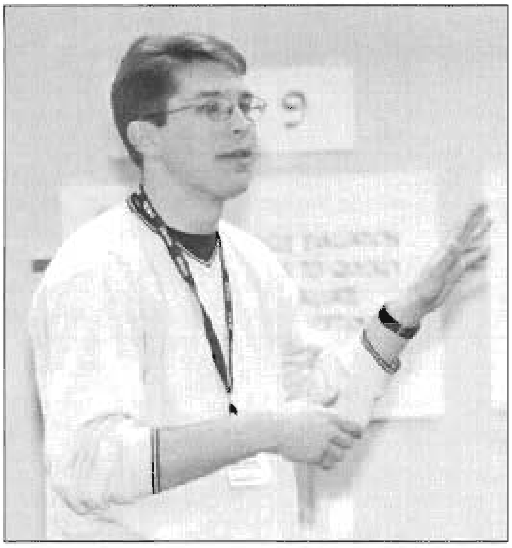
Importance:

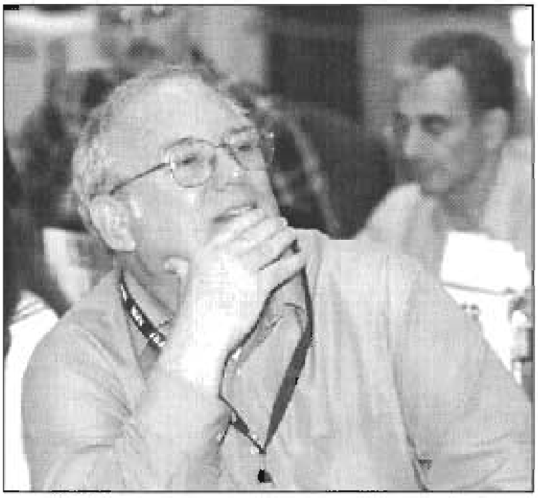
- We have lost the public's confidence; we need to restore it jointly (industry, federal, and state governments). There is no national focus on resolving the problem.
- The development of regional "boutique fuels" and state-by state clean-up standards misses the mark and is symptomatic of the problem.

How Do You Propose Addressing This Issue?

Government may require industry to adhere to a much more stringent analysis of new petroleum compounds:

- Require stringent testing and review of new fuel additives.
- Evaluate the economic impacts of the compounds assuming worst-case scenario—they are released into the environment.
- Create a National Fuels Task Force that will use as its starting point the recommendations of the Blue Ribbon Panel on MTBE: a "stakeholders group" of industry, government, citizens, and other representatives.





PRIORITY 10

Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern

Originators:

Skone on behalf of himself, Curran, Durkee, Handley, and Wang

The following issues were consolidated under the following title:

Title: **The Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern**

Originator: Skone

Issue Description:

The topic of "impacts related to transportation fuels" is very broad. Before we begin to characterize the impacts of concern, we must clearly define the purpose of the LCA (what is the question we are trying to answer?) and the system boundaries that need to be applied to achieve the purpose of the LCA. Once these are clearly defined, we can then begin to balance the potential impact of alternative transportation fuel options.

Importance:

The purpose defines the boundaries; the boundaries, combined with the selection and modeling of impacts, will define the extent to which the results can be interpreted. As we all know, the current body of scientific knowledge to model or determine the impacts of different fuel options is limited, particularly with respect to fate and transport mechanisms.

How Do You Propose Addressing This Issue?

First and foremost, I would like to emphasize that an LCA is not a one-stop-shop decision-making tool. The LCA results must be combined (meaning brought forward) with other key decision-making information (e.g., benefit-cost analysis, economic impacts, social consideration, risk analysis, etc.) developed on the same boundary and assumptions to the greatest extent

possible. When different, these need to be explained to the decision maker in a transparent manner.

Second, as a workgroup, we need to clearly define the purpose of the LCA under discussion and then determine the boundaries, assumptions, and available data sources capable of achieving the goal.

Title: **Functional Unit**

Originator: Skone

Issue Description:

The LCA uses a term called "functional unit" to define the basis by which one or more alternatives shall be compared. Examples: the propulsion of one 3,200-pound light-duty passenger vehicle 12,000 miles in 1 year, or the propulsion of the U.S. light-duty passenger vehicle fleet from the years 2002 to 2017 (15-year time period). As you may notice, the functional unit is a technical performance definition that is independent of the fuel option. This is a critical component of an LCA.

The second step is to define the alternatives (fuel options) and the actions that need to occur to meet the functional unit (i.e., definition of the fuel-cycle system boundaries with respect to time). Time? Yes, the boundaries and assumptions used to develop the LCA can be established as those for accompanying benefit-cost analysis and project (fuel-option) implementation schedules. Building from the 15-year time period functional unit described earlier, the LCA can (and should be) structured to account for the environmental impacts associated with the construction of new manufacturing facilities, infrastructure upgrades/changes, and the rates at which the alternative will be phased into use over the time period.

Importance:

Clearly defining the functional unit will establish a consistent and fair basis for comparing and interpreting the results of the study. This functional unit must be applied to the other types of decision-making tools employed to evaluate fuel options. If not, it will be difficult for any decision maker, policy analyst or regulator, and scientist to make an informed decision.

How Do You Propose Addressing This Issue?

Coordinate multiple stakeholders and subject matter experts (as we have here today) to define and agree upon a functional unit and a set of project assumptions and system boundaries by which decision-making analyses and studies are developed to ensure an equal and fair interpretation of the results.

***

Title: **A Comprehensive Life Cycle Evaluation Should Strive to Be Cradle-to-Grave and Cover Multimedia Environmental Impacts**

Originator: Curran

Issue Description:

Studies that are called life cycle evaluations, but do not include all the life cycle stages or all media (e.g., air, water, and solid waste), only give part of the story.

Importance:

It is important to fully evaluate trade-offs that will occur when changing a product system or selecting one over another.

How Do You Propose Addressing This Issue?

Follow ISO 14040 guidelines on LCAs.

***

Title: **There Is a Need for Coordinated and Comprehensive Assessments Early on and in Repetitive Fashion over the Years as a "Standard Way of Doing Business"**

Originator: Durkee

Issue Description:

Comprehensive assessments are useful to decision makers in identifying uncertainties and data gaps concerning whether these may be potential problem(s). We should not wait until "all the data" are available before undertaking a "grand assessment." The potential policy decisions go beyond the question of "fuel choice" to a number of options to address problems with fuels.

Importance:

This is important to break out of a "crisis mode."

How Do You Propose Addressing This Issue?

This is part of marketing the uses for comprehensive analysis. Therefore, "solutions" include conferences like this.

Title: **Life Cycle Assessments Should Consider Regional Variations**

Originator: Handley

Issue Description:

Regional variations such as climate, geology, and political structure need to be considered within a LCA.

Importance:

For example, the impacts of acetaldehydes or peroxyacetyl nitrate may not be a factor in one region; due to differences in ambient levels, sunlight, and climate, they may have more significant impacts in other regions. Likewise, ambient conditions related to carbon monoxide and VOCs may have regional variations.

How Do You Propose Addressing This Issue?

Regional subgroups should be empaneled to provide input and review of LCAs.

Title: **Include All Potential Environmental Impacts on a Systematic Basis to Clearly Address and Debate Environmental Trade-offs of Alternative Fuels**

Originator: Wang

Issue Description:

- All potential environmental impacts: urban air pollution, greenhouse gas emissions, energy impacts, water pollution, and other ecological effects.

- Systematic basis: follow a well-designed LCA protocol so that all the key processes are thoroughly analyzed. This includes definition of system boundary, applications of sound analytic methodologies, and use of up-to-date data.

- Environmental trade offs: there is no such silver bullet to solve all the environmental problems. An LCA should provide helpful information on environmental effects on all media (air, water, soil, etc.) so society can evaluate the positive and negative effects to make sensible trade-off decisions.

Importance:

As described above.

How Do You Propose Addressing This Issue?

Convene an expert panel, interagency working group, etc. to develop protocols. An LCA is a mean, not the end.

Title: **A Life Cycle Assessment Is Not an End, But a Mean, and It Is a Limited Mean**

Originator: Wang

Issue Description:

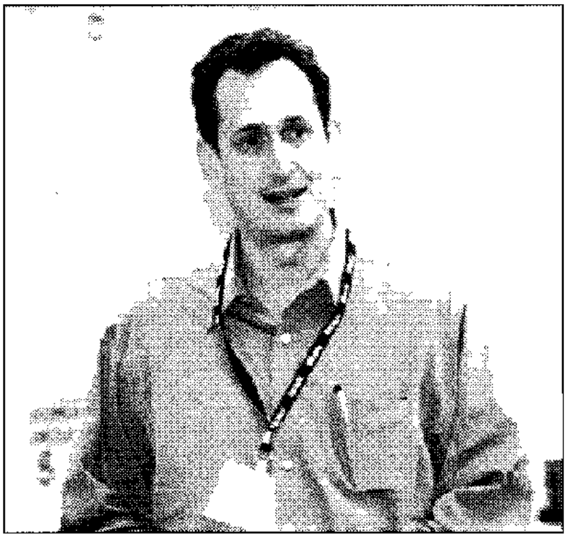
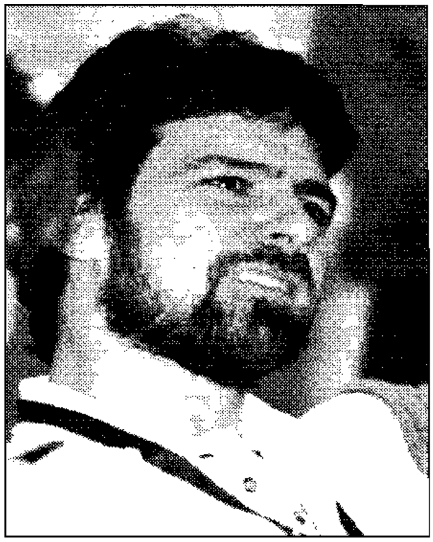
An LCA is a limited tool to address energy and environmental effects of a given technology. An LCA should not be expected to address economics, consumer acceptance, politics, etc. Some may argue that an LCA should be extended to include these issues. That will be a new discipline.

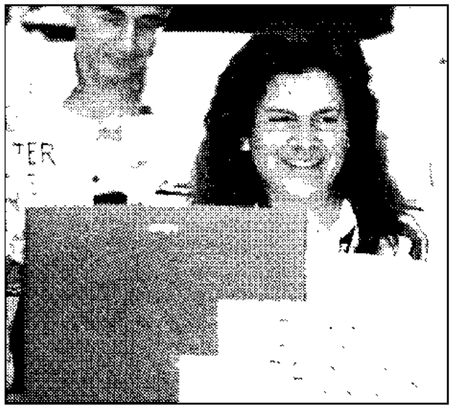
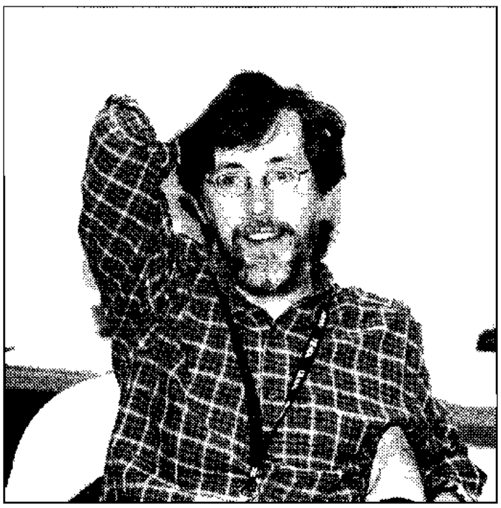
The LCA results should be used within its scopes and are part of the debate of adopting or not adopting a new fuel. An LCA, together with results from other disciplines (e.g., cost-benefit analysis, consumer acceptance, infrastructure constraints, etc.), helps the decision-making process.

An LCA's best ability is to identify bottleneck issues in environmental effects. That is, an LCA should not be treated to provide static results for a given fuel or pathway; it should be treated to identify what can be improved and what cannot be inherently improved for a given technology in a dynamic process. That is, an LCA may help us look forward to potentials and limitations of fuels.

How Do You Propose Addressing This Issue?

Improve communications with policy makers to convene the usefulness and limitation of LCAs.

PRIORITY 11

Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels

Originators:

Alvarez on behalf of himself, Davidson, Deeb, Drogos, and Sheehan

The following issues were consolidated under the following title:

Title: **Groundwater Quality Impacts Associated with the Release of Alternative Fuels**

Originator: Alvarez

Issue Description:

Groundwater pollution has traditionally been, and is likely to continue to be, a common environmental impact associated with transportation fuels. We need to evaluate the likelihood that these fuels and their additives or byproducts will impact drinking-water wells. Broad issues may include toxicity, aesthetic impacts to water quality (e.g., taste, odor, color), explosion hazards from methane generation, and mobilization and elongation of pre-existing contaminant plumes (e.g., BTEX).

Importance:

This is a part of evaluating environmental interventions and is important for risk assessment and management.

How Do You Propose Addressing This Issue?

Laboratory studies (microcosms and flow-through columns) are needed to characterize fate and transport under different conditions and to provide a basis for mathematical modeling. Eventually, we may want to conduct a controlled release study to characterize the dimensions and stability of the plumes; validate the models with field data; and provide a test bed for novel sampling and analytical techniques.

Title: **Estimate the Fuels' Media-Media Transfer Potential throughout the Hydrologic Cycle and Put the Results in Context**

Originator: Davidson

Issue Description:

Experience has shown that we often use a product to solve a problem without thinking about the impact of the product and its byproducts all the way through. Also, we need to have experts in each predicted impacted media to review the results and put them in to perspective (e.g., what does 10 ppb of benzene in a drinking-water reservoir mean?).

Importance:

- To eliminate unnecessary oversights about occurrence.
- To put the predicted occurrence into perspective.
- To avoid "compartmentalization" of knowledge that can plague some broad studies.

How Do You Propose Addressing This Issue?

- Use physico-chemical characteristics to estimate the possibility of media-media transfer for the many environmental pathways.
- Have a panel of experts for each media (e.g., air, soil, water, drinking water) put the findings into context.

Title: **Impact of Alternative Fuels on the Attenuation of Past Organic and Inorganic Contaminant Releases**

Originator: Deeb

Issue Description:

It is important to evaluate the impact of alternative oxygenates (e.g., ethanol) and fuels considered for future use (e.g., 100-percent methanol for use in fuel cell vehicles) on the fate and transport of gasoline components from past fuel releases, including compounds such as benzene, MTBE, and TBA. Alcohols are far more biodegradable than alkanes, aromatics, ethers, and alkylates. While this is advantageous regarding the fate and transport of alcohols (i.e., they will

not persist in subsurface environments and in surface water), their biodegradability and, therefore, the potential depletion of oxygen, other electron acceptors, and nutrients can have a detrimental effect on the fate and transport of co-occurring contaminants. While some studies have addressed the impact of ethanol on BTEX plume elongation, the impact of alcohol oxygenates on the natural attenuation of MTBE has not been investigated. In addition, it is important to evaluate how changes in subsurface redox conditions potentially impact the mobility of inorganic contaminants, such as chromium, arsenic, etc.

Importance:

Natural attenuation rates of contaminants (e.g., BTEX, MTBE, TBA) from past fuel releases can be negatively impacted due to co-solvency and/or changes in redox conditions in the subsurfaee resulting from the introduction of large volumes of alcohols. In addition, changes in redox conditions could re-mobilize subsurface inorganics of concern. This can lead to site management complications as well as remedial challenges, potentially leading to increases in cost and a decrease in the possibility of meeting regulatory clean-up standards.

How Do You Propose Addressing This Issue?

Studies by multidisciplinary teams at a variety of levels are needed, starting with laboratory batch and column studies and ending with field studies, including controlled releases.

Title: **Environmental Fate, Transport, and Biodegradation Studies of Fuels and Fuel Compounds in Groundwater**

Originator: Drogos

Issue Description:

- Conduct studies of the fate, transport, and biodegradability of fuel compounds and fuel formulations in the subsurface environment before they are placed into the fuel supply.
- Evaluate the fate, transport, and biodegradability of the new fuel compounds and fuel formations when commingled with existing contaminant plumes.
- Identify the daughter products of degradation and determine their threats, if any, to the environment.

Importance:

- To identify any potential threats to groundwater posed by new fuel compounds before they are placed into the nation's fuel supplies.
- To identify potential threats to groundwater posed by compound-specific adjustments to fuel formulations. For example, the use of ethanol in fuel required an increase in the amount of alkylates traditionally used in fuel formulations, which necessitated an evaluation of the environmental effects of alkylates in addition to the effects from ethanol.

How Do You Propose Addressing This Issue?

Perform bench-top and field-scale studies at universities or research facilities.

Title: **Current Life Cycle Analysis Does Not Address Water Quality**

Originator: Sheehan

Issue Description:

The complexity of water-quality issues has impeded our ability to account for water impacts in fuel choices. If life cycle analysis is defined as "comprehensive," then we must admit that, without accounting for water-quality effects, all of our attempts at life cycle analysis are, by definition, failures.

Importance:

A spokesperson for the World Resources Institute recently stated quite plainly that water quality is the number one environmental problem facing us today. Proposals for energy crops and for using agricultural residues could involve serious water-quality problems. These impacts must be understood before moving ahead with research and development investments and policy decisions.

How Do You Propose Addressing This Issue?

Conduct life cycle analysis using multidisciplinary teams that bring together expertise, as needed, to address all impacts, particularly in water quality. Not only do specialized models fail to talk to each other, but the experts themselves do not talk to each other.

PRIORITY 12

Define Downstream Socioeconomic Impacts of Manufacturing Choices

Originators:

Moller on behalf of himself, Dooher, Reynolds, and Salmon

The following issues were consolidated under the following title:

Title: **Define Downstream Socioeconomic Impacts of Manufacturing Choices**

Originator: Moller

Issue Description:

What are the various potential social impacts associated with the choice to manufacture one fuel component instead of another or the choice of one manufacturing process over another?

Importance:

There could well be a number of "domino" effects associated with the choice to manufacture a given fuel or fuel component. For example, putting corn supplies into ethanol production could have an adverse impact upon the markets for alternative products, such as fructose syrup (the "food versus fuel" debate). Also, the choice to manufacture increasing amounts of ethanol has the effect of depleting the Federal Highway Trust Fund by virtue of the gasoline tax credit afforded to ethanol blends. Another concrete example involves the manufacture of alkylate. The popular manufacturing process for alkylate involves the uses of hydrofluoric acid, which some critics have said increases the risk of personal injury to refinery workers and members of neighboring communities.

How Do You Propose Addressing This Issue?

For each alternative fuel component, an analysis must be performed on each of the available manufacturing processes and the variety of social impacts associated therewith. Does the particular process present an inordinate risk of personal injury to workers or neighbors? Does the process lead to an over-commitment of a raw material of limited supply such that the markets for alternative products are affected? Does the decision to manufacture a particular fuel have any other negative societal impacts in terms of tax revenues, environmental civil rights, or the like?

Title: **Non-energy Governmental Policy Considerations, Foreign and Domestic**

Originator: Moller

Issue Description:

What impact will the fuel alternative choice have upon U.S. policies pertaining to domestic taxation and international trade?

Importance:

Since gasoline is subject to considerable domestic taxation and can be subject to import tariffs, the selection of alternative fuel components may have a substantial impact upon tax revenues and trade policy. One example is ethanol. The increased use of ethanol will have a significant impact upon inflow to the Federal Highway Trust Fund. At the same time, the U.S. will be put under greater pressure from foreign trading partners who are sources of ethanol to repeal the tariff on foreign ethanol imports. The leverage held by other countries is to impose counter tariffs upon U.S. goods, which could have a significant impact upon other U.S. industries.

How Do You Propose Addressing This Issue?

For each alternative fuel component, the potential tax and free trade implications must be analyzed.

Title: **Introducing Security and Potential Trade Concerns into Life Cycle Assessments to Help Developan Economically Profitable, Sustainable, and Secure Future**

Originator: Dooher

Issue Description:

September 11, 2001, made the United States government and public much more aware of the security and economic issues associated with living in a more dangerous world. An LCA would benefit from looking at not only different fuels, but at the transition rates and the overall economic benefits or costs associated with different transitions to other fuels and transportation technologies, keeping in mind security and potential trade benefits. An LCA should examine not only domestic issues, but international issues, such as the advantages of technology developed in the U.S. being introduced into developing countries, to assist these countries in reducing poverty and population growth. The goal would be to examine if new energy and fuel paths will introduce stability and security, both here and abroad. The change agent must be the U.S., as only it has the economic, technological, and political sway that can influence the rest of the world.

Importance:

An LCA should seriously assess the advantage of the U.S. in achieving energy independence. The public mood is right for such a discussion, especially if the political will is supportive. An LCA can assess the benefits of new technology and the resulting trade benefits to U.S. employment and economic growth. Over the last 30 years, it is has been estimated that the U.S. has paid some $7 trillion in current dollars for oil imports (with the range of estimates being between $3.5 and $14.6 trillion in current dollars). With increasing population growth and fuel usage here, this cost will be significantly larger over the next 30 years. The potential for growth within the U.S. of redirecting such vast future sums to a domestic fuel production economy is evident. Additionally, an examination of the vulnerability of various fuel supplies is warranted—as an example, what would the effect of a large-scale drought or biological attack on fuel/food crops have on the U.S. economy, if a large percentage of our fuel was grown? What about concerted terrorist attacks on oil transport tankers shutting down imports? LCAs should seriously address these issues.

An LCA should attempt to examine areas for investment in fundamental research and development that would bring the most rapid results and economic benefits. An LCA should examine the transportation and energy needs of developing countries, considering specific application of various fuel and energy technologies with varied cost structures and resource bases. The advantage to other countries sustainability and development requirements that would come from skipping intermediate levels of fuel and transport development should also be considered. This LCA effort should examine the rapid diffusion of technology into developing

countries. Such diffusion of technologies into developing countries would have multiple goals, such as speeding economic development, ultimately reducing birth rates, and eliminating the predicted carbon dioxide and other pollutant production that would result if developing nations follow the same energy path as the U.S.

How Do You Propose Addressing This Issue?

A roadmap for a possible LCA of these issues should attempt to integrate within it such areas as:

- Technical and engineering requirements.
- Political and social interactions and issues.
- Regulatory restrictions and opportunities.
- International and trade issues.
- Economic and financial requirements.

Without trying to integrate all of the above, at an international level, an LCA will "miss the boat" of opportunities that are presented to us.

Title: **International Standardization and Global Harmonization Issues**

Originator: Reynolds

Issue Description:

Various issues may be decided based on an LCA. Consequently, international cooperation on developing LCA inputs and values is important. Ideally, while some values would be the same across borders, the application of certain country-specific data should be considered, since it could result in unique considerations.

Importance:

If different countries go in different directions, it is, or could be, counterproductive to global harmonization efforts; for instance, in automotive technologies, such as fuel cells and emission control technologies. Also, different countries may have unique considerations with regards to natural resources and existing infrastructure or lack thereof. An accurate model would likely project different results based on such factors.

How Do You Propose Addressing This Issue?

There is a need for an international group that considers the work being done in each country, or group of countries to strive for some level of parallelism in model development.

Title: **Identify and Characterize the Differential Health and Environmental Impacts to Different Sections of the Community**

Originator: Salmon

Issue Description:

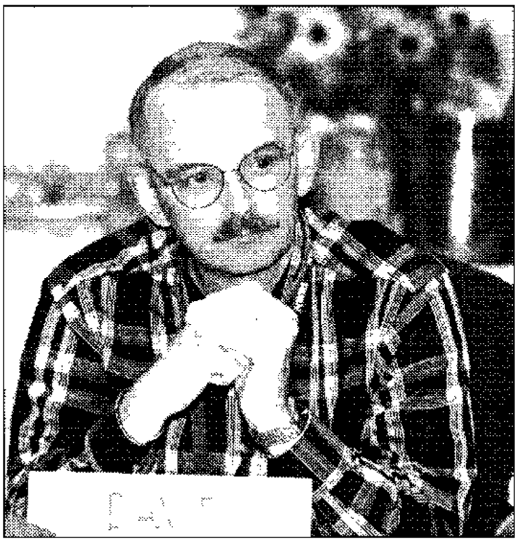
Adverse impacts on health and the environment frequently have the most severe impact on sections of the community (e.g., the poor, minority groups) that do not receive the full range of economic benefits. The analysis of risks and benefits needs to reflect this problem. It is critical to characterize actual data and analysis, not opinion/rumor, etc.

Importance:

If this issue is not addressed, a proposal may be inappropriately selected and, thus, run into major political and social problems down the road.

How Do You Propose Addressing This Issue?

- Recognize the problem. It is not entirely soluble at the technical level.
- Make sure that all the costs are accurately represented and distributed, including costs of remediation to improve environmental justice.
- Regulation of existing solutions to improve cost distribution; avoid perpetuating existing injustices.



PRIORITY 13

Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution, and Use of Various Biologically Based Fuel Options

Originators:

Smith on behalf of herself, Alvarez, Drogos, Layton, and Powers

The following issues were consolidated under the following title:

Title: **Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution, and Use of Various Biologically Based Fuel Options**

Originator: Smith

Issue Description:

Biologically based fuel options include biofuels, oxygenates (e.g., methanol and ethanol), and hydrogen from microalgae or microorganisms. For example, direct impacts of the production of biofuels and fuel additive products may include increased farming on "wild" or marginal lands. Indirect effects of production may include increased pesticide, fertilizer, and water use. The use of genetically modified crop plants may increase the risk to non-target organisms.

Importance:

There is an existing impact from agricultural practices on ecosystems and ecologic receptors. The extent to which biologically based fuel options may contribute to additional environmental impacts should be considered.

How Do You Propose Addressing This Issue?

- Identify several "model scenarios" (e.g., biofuels, using genetically modified organisms [GMOs], agricultural waste streams, manure, and/or straw; and oxygenates, using GMOs, pesticides, fertilizers, and water).

- Gather a multidisciplinary interagency group (e.g., USDA, USEPA, U.S. Food and Drug Administration [USFDA], USGS, states, and other stakeholders) to model potential environmental impacts.
- Provide this information to decision makers.

Title: **Gene Pollution**

Originator: Alvarez

Issue Description:

Genes are likely to become an important category of environmental pollutants in the future as observed by increases in antibiotic resistance among bacteria that acquire appropriate gene vectors. We may see an increase in the use of genetically engineered phototrophic microorganisms to produce hydrogen from water, and genetically modified plants with enhanced yields of critical raw materials or biocatalysts. However, little is known about how these genes behave and transfer from one species to another in the environment, which in turn may affect the ecological balance and biodiversity.

Importance:

This is a potentially important issue in the relatively distant future, which may affect biodiversity and is thus relevant to ecological risk assessment.

How Do You Propose Addressing This Issue?

Conduct laboratory studies to investigate inter- and intra-species gene transfer and the fate and transport characteristic of gene vectors in the environment (modeling studies would also help). In summary, treat some genes as potential environmental pollutants.

Title: **Availability and Effects of Natural Resources for Biofuels**

Originator: Drogos

Issue Description:

When evaluating the use of biofuels (e.g., biodiesel, ethanol, etc.) consider:

- The availability of raw materials. What would be the effects of blights, freezes, floods, or other agricultural constraints on the ultimate availability of the fuel in the market? Identify any safeguards needed to ensure that an uninterrupted supply of fuel reaches the market (i.e., stockpiling of corn for ethanol production, import of raw materials, etc.).

- Concerns regarding a potential increase in the amount of genetically engineered crops and their effects on non-engineered crops grown in the vicinity.

Importance:

A widely available and reliable supply of fuel, which is also cost effective, is needed for the marketplace.

The issue of genetically engineered crops and their potential health risks to the food supply has not been evaluated. An increase in production of genetically engineered crops could affect crops for human consumption, if adequate safeguards are not in place.

How Do You Propose Addressing This Issue?

- Evaluate the fuel consumption needs in the U.S. and the potential loss of fuel supplies to agricultural problems.

- Evaluate the pathway of genetically engineered crops to market and evaluate the health effects of genetically engineered crops.

Title: **Resource Consumption Must Become a Fundamental Component of Life Cycle Assessments of Fuel Compounds**

Originator: Layton

Issue Description:

The production of liquid fuels, such as Fisher-Tropsch Diesel fuel from natural gas, can consume significant amounts of water and other resources. Similarly, renewable transportation fuels derived from corn and other agricultural products will require expanded acreages of arable land. Can such fuel production technologies be sustained by a region's natural resources?

Importance:

With limits on land and water resources across the U.S. and elsewhere, it is imperative to address the sustainability of a given fuel production cycle, based on the consumption of natural resources.

How Do You Propose Addressing This Issue?

Resource use assessments should be addressed on a site-specific basis. Methodologies must be developed.

Title: **Determining the Added Value of Fuel Derived from Waste Materials**

Originator: Powers

Issue Description:

The feed stocks for alternative fuels (methyl alcohol, ethyl alcohol, methane, and hydrogen) can be quite varied, including:

- "Virgin" materials (natural gas).
- Those that could be used beneficially for other uses (corn→food instead of ethanol).
- Waste products (e.g., agriculture or industrial waste→ethanol).

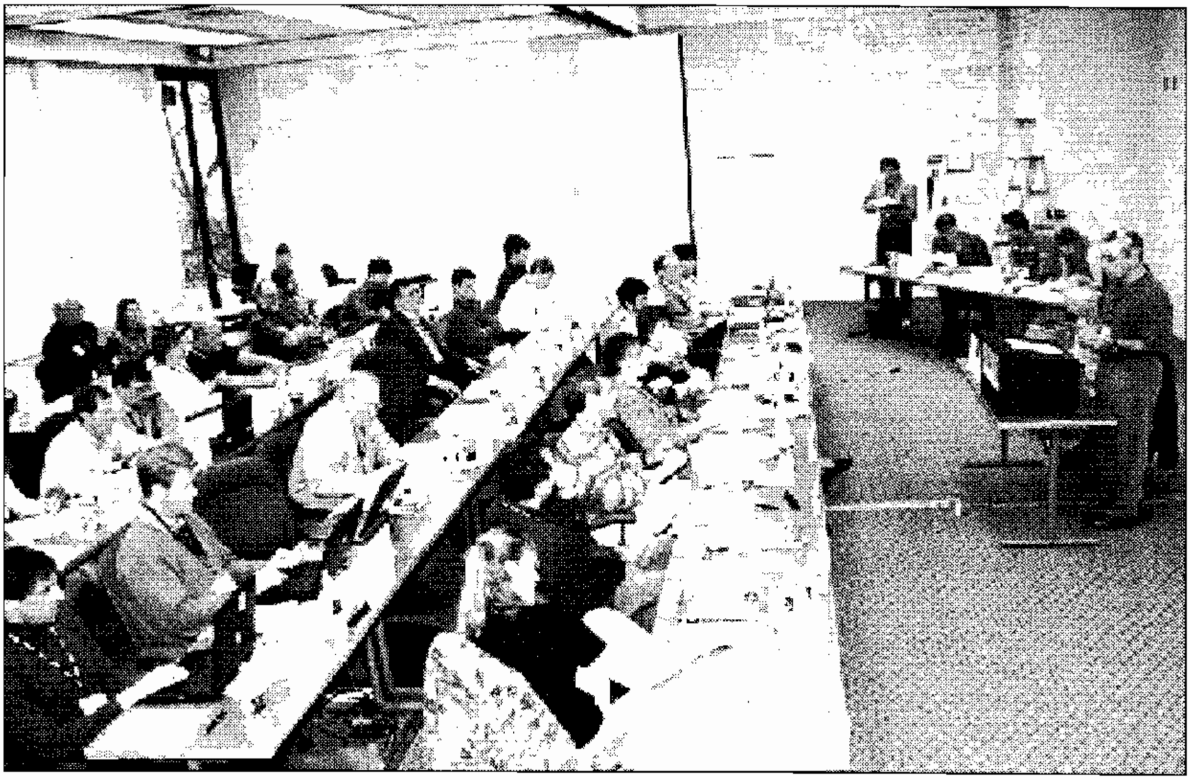
Many current life cycle methods fail to adequately capture the added value of generating fuel from waste materials.

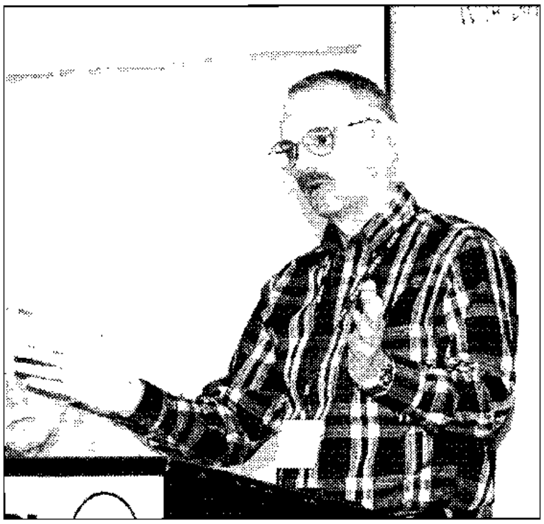
Importance:

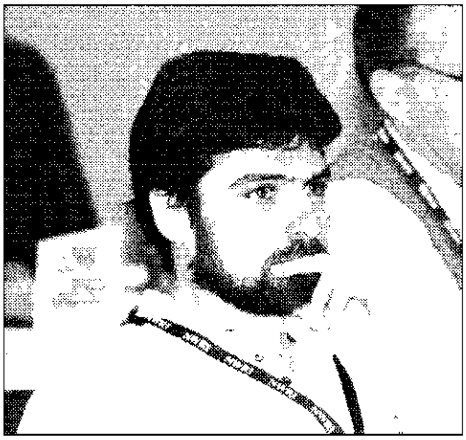
The development of waste material feed stocks can help to move towards a true industrial ecology. It is recognized that those sources will not meet national fuel needs, but they could be critically important on regional scales.

How Do You Propose Addressing This Issue?

The best means of conducting an LCA that incorporates the added value of using waste products must be evaluated and implemented. This would necessarily need to include the cost and benefits of externalities not currently considered.







PRIORITY 14

Need Performance Criteria to Evaluate the Pollution Potential of Fuel Compounds to Define Their Attenuation in Environmental Media and the Effectiveness of Remediation, Control, and Treatment Technologies

Originators:

Layton on behalf of himself, Davidson, and Deeb

The following issues were consolidated under the following title:

Title: **Environmental Performance Criteria Need to Be Developed to Evaluate Fuel Compounds**

Originator: Layton

Issue Description:

If the transport and fate of a fuel compound in the environment is a complex function of its physicochemical properties, chemical structure, and the characteristics of the environmental media in which it resides. In the absence of performance metrics (e.g., half-life in soil or water), it is not really possible to decide whether a given compound will harm or degrade the environment.

Importance:

To facilitate the development of fuel compounds, there must be performance guidelines that can serve as benchmarks against which the behavior of a fuel can be evaluated. Such performance criteria will help ensure that fuels are developed that are not inferior to existing ones.

How Do You Propose Addressing This Issue?

Research needs to be conducted on how best to develop applicable performance measures.

Title: **Ensure Clean-up Technologies Exist for a Fuel/Fuel Additive and Its Byproducts Before the Product Is Commercially Used**

Originator: Davidson

Issue Description:

Whatever fuel/fuel additive we use, there will be some accidental releases because human error and mechanical failure will, unfortunately, happen. It is unwise to start extensive use of a product without knowing how to clean it up; otherwise, we will struggle to play catch-up with our clean-up technologies while public concern rapidly rises. Also, the public is trusting us to have technology solutions ready when needed.

Importance:

- It is illogical to start using a product commercially without knowing how to clean it up.
- Experience has shown the inefficiency, waste, and unnecessary stress caused by trying to develop technologies on a "we need it now" basis.
- Reviewing clean-up technologies in advance may reveal that existing options are fine, need modification, or are totally inadequate. These each have quite different environmental and fiscal implications.

How Do You Propose Addressing This Issue?

- Have experienced scientists and engineers compare measured and/or predicted environmental occurrence of the fuel/additive/byproduct against existing and emerging remediation and treatment technologies.
- Identify any modifications to existing technologies that might be needed.
- If needed, identify and develop new clean-up technologies.
- If needed, stop commercialization of an environmentally adverse product if we cannot clean it up with reasonable applications of technology.

Title: **Consider Developing Water-quality Standards for Potentially Large Production Volume/Use Chemicals in the Fuel Industry**

Originator: Deeb

Issue Description:

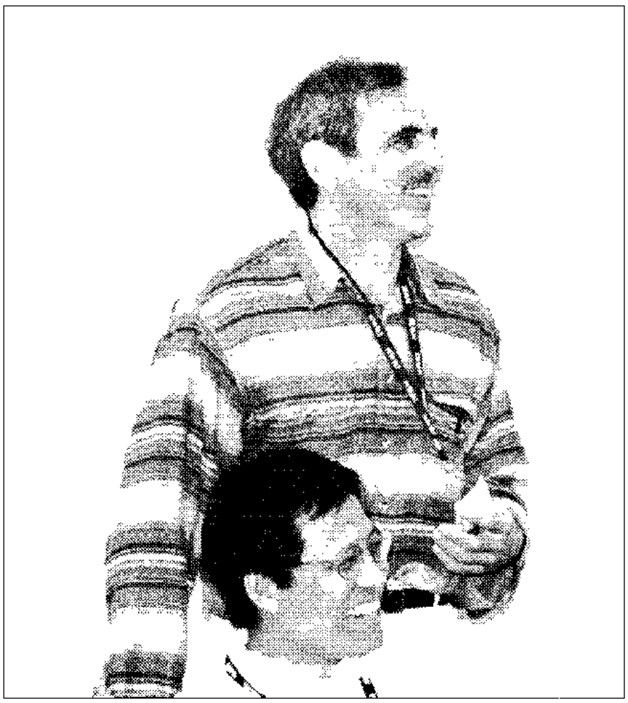
Develop water-quality standards for ethanol, methanol, TBA, MTBE, alkylates, and other additives/impurities in fuels.

Importance:

Much is known about the acute toxicity of most fuel components. It is important to evaluate the health impacts resulting from long-term exposure to low levels of these potential water contaminants. Perhaps any chemical that is produced in large volumes should be considered as a potential emerging water contaminant. If so, should a water-quality standard be developed for these chemicals prior to their use?

How Do You Propose Addressing This Issue?

Most of the compounds of interest here, especially alcohol oxygenates, are not likely to impact drinking water supply wells directly. If they do reach and contaminate water supplies, alcohols are likely to be present at low concentrations. Does this merit going through a process to set a drinking-water standard? Regulators and industry can perhaps work together to resolve this issue.



PRIORITY 15

Expand Air Emissions Analyses for Alternative Fuels Blended in Gasoline to Include Both Off-Road Gasoline Engines and Future Vehicle Benefits

Originators:

Piel on behalf of himself and Andress

The following issues were consolidated under the following title:

Title: **Expand Air Emissions Analyses for Alternative Fuels Blended in Gasoline to Include Both Off-Road Gasoline Engines and Future Vehicle Benefits**

Originator: Piel

Issue Description:

The envelope for emission analysis needs to widen to capture all emission benefits. Currently, emission benefits from blending alternative fuels in gasoline is usually limited to that from current vehicle fleets or past vehicles. Fuel effects on off-road engine emissions are usually ignored because they consume only about 5 percent of the gasoline but, unfortunately, generate 25 to 40 percent or more of the emissions inventory from gasoline-consuming engines. Since these engines have less sophisticated emission controls, they are usually more sensitive to some fuel effects than that observed in vehicles. They also generate many more VOCs (and toxics) than NO_x.

Separately, many policy makers believe that newer vehicle emissions are insensitive to fuel quality or component effects, while actual emission studies suggest that they are just as sensitive. Very low emissions with future vehicles, such as ultra-low emission vehicles (ULEVs), can only be achieved by guaranteeing the cleanest gasoline fuel in the marketplace; therefore, the flexibility provided by cleaner fuel components, which allow the automakers to design even lower emission vehicles, needs to be captured in the emission benefits analysis of alternative fuel blends.

Importance:

To truly evaluate alternative fuel blending benefits, the emissions analysis for blending cleaner alternative fuels into RFGs needs to be expanded beyond current vehicle fleet emissions to also include emission effects from off-road engines as well asthe flexibility it provides automotive fuel system designers to put more ULEVs on the street. When we evaluate alternative fuel vehicles, we make the comparison with a vehicle optimized for that fuel. We need to do the same for cleaner gasolines using alternative fuels.

The largest environmental benefit from alternative fuels is to reduce emissions from the gasoline engine population by 20 to 50 percent from all sources; therefore, all the existing and potential future emission benefits with new engine designs need to be understood and captured in an LCA.

How Do You Propose Addressing This Issue?

Automakers are in the best position to understand what fuel effects provide emission benefits in existing vehicles and in emission design flexibility provided by cleaner gasolines; therefore, automakers should have more access in the fuel life cycle process. Also, emissions studies need to be expanded to include off-road engines emissions.

Title: **Expand Emission Analyses for Blending Alternative Fuels in Gasoline to Also Include Ozone Yield Reactivity, Primary Particulate Material, and Particulate Material Aerosol Effects**

Originator: Piel

Issue Description:

The envelope for emission analysis needs to be widened to capture all emission benefits from blending alternative fuels in gasoline or diesel. Currently, for controlling peak ozone and mobile source toxics, policy makers on fuel quality generally limit themselves to only the effect on regulated "mass" emissions of VOCs, NO_X, carbon monoxide, and possible toxics out the tailpipe; however, the ozone yield from the type of gasoline hydrocarbon emission from vehicles can vary by almost an order of magnitude. The reaction of summertime carbon monoxide also plays a significant role for production of peak ozone. Separately, recent particulate material 2.5 inventory sampling suggests that organic aerosols, such as those from atmospheric oxidation of aromatics, may contribute the largest share of particulate material inventory in much of the U.S.

For controlling levels of peak ozone and particulate material 2.5 in the atmosphere, the emissions analysis needs to be expanded to include the ozone yield reactivity of hydrocarbon type used in the fuel. It also needs to be expanded to include both the primary particulate material and secondary particulate material aerosol effects of the various fuel components.

Importance:

Emission analysis suggests that gasoline VOCs from the vehicle fleet and off-road engines will still be the largest contributors to peak ozone in the future, because many of them are high-ozone-yielding VOCs; therefore, the ozone yield reactivity needs to be captured in fuel emission analysis or modeling.

Also, a chemical analysis of particulate material inventories suggests that the role of secondary organic aerosols has been understated. Since alternative fuels blended into gasoline will likely have lower ozone yield reactivity and will also lower particulate material contribution, the size of these benefits needs to be included.

How Do You Propose Addressing This Issue?

These secondary effects on peak ozone and particulate material aerosols can be very large and, unfortunately, fall outside the current regulatory models or prediction tools provided by the USEPA to the states. These secondary effects need to be better understood and incorporated into the current modeling tools. The current models are geared only to controlling the mass emissions of ozone precursors and do not capture these secondary atmospheric effects.

Title: **Increased Coordination and Integration of Fuel and Vehicles**

Originator: Andress

Issue Description:

A coordinated approach incorporating fuel and vehicle integration can achieve significant reductions in vehicular emissions and concomitant increases in fuel economy. For example, proposed renewable fuel content standards will increase the use of ethanol. Automotive engineers are aware of a number of techniques that will improve vehicular performance and emission reductions when ethanol fuels are used; however, directed research is needed to flush out the technology and reduce costs to the competitive range.

Importance:

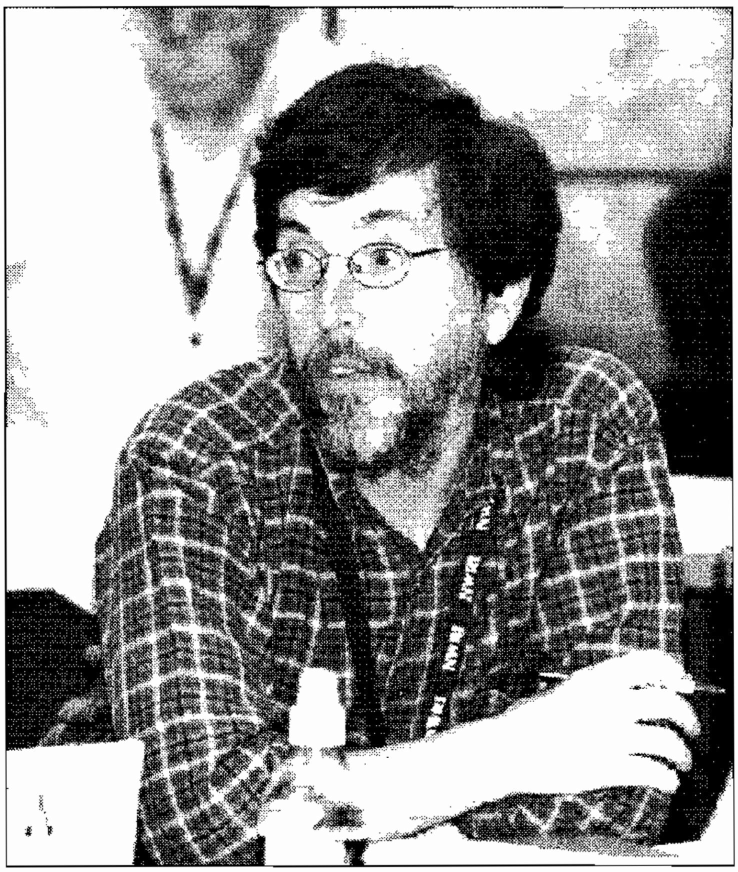
- Most reductions in mobile source emissions is due to advances in vehicular emissions control systems.
- Controlling some fuel properties, such as sulfur, is essential for advanced emission control systems.

- Advances, such as lean burn catalysts, will significantly reduce NO_x emissions and facilitate lean fuel operations that will benefit both oxygenated and diesel fuels. Lean conditions increase fuel economy and will reduce VOC emissions.

- Better evaporative emissions control will take the pressure off low RVP fuels, reduce tailpipe VOC emissions, improve Distillation Index characteristics, improve gasoline produceability, and facilitate improvements in emission control calibration.

How Do You Propose Addressing This Issue?

Conduct working sessions involving automakers, fuel suppliers, regulations, policy makers, etc.



PRIORITY 16

Use Life Cycle Analysis as a Tool for Making Ethical and Political Choices in Support of Sustainable Development

Originator:

Sheehan

Issue Description:

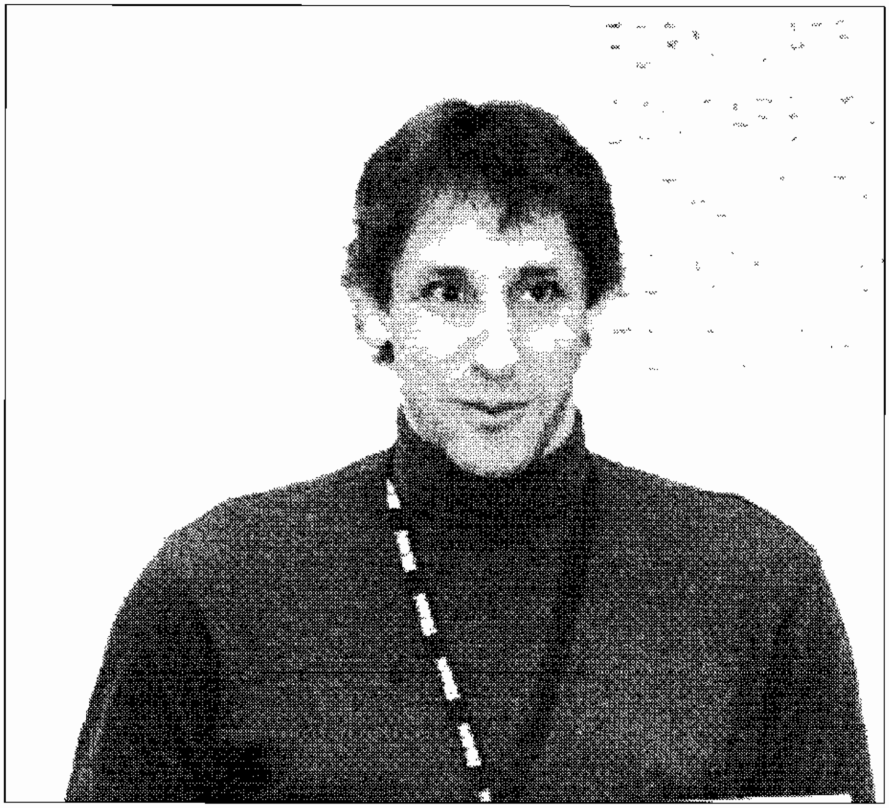
Life cycle analysis is a framework for making choices. Today, it is used to do "bean-counting," of environmental impacts. If we stop there, we have not taken advantage of life cycle analysis as a tool for making sustainable choices. Sustainable choices involve social, ethical, and economic impacts, as well as the basic energy and environmental flows we typically consider.

Importance:

We need to move issues like "fuel choice" out of the realm of "experts" and to empower people to understand and choose among the trade-offs that all fuels offer. Replacing petroleum will take decades, so this discussion is needed today. Until we bring the public into this dialogue, we will continue to randomly jump from one proposed "quiek fix" to another. Today, our policy makers have landed on hydrogen as the answer with little or no concern about its genuine sustainability.

How Do You Propose Addressing This Issue?

The process is the product. We need to conduct life cycle studies for fuel choices by bringing stakeholders together early in the process to set goals and the scope of the studies. We should also bring these stakeholders together throughout the study, and strive for a consensus on what is known and what is not, as well as what is a matter for science and what is a matter for ethical and political decision making.



PRIORITY 17

Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses

Originator:

Delucchi

Issue Description:

LCAs often measure several different kinds of environmental impacts: different air pollutants, water pollutants, climate change gases, oil use, and so on.

Importance:

Because it almost always is the case that no one alternative dominates the others on all criteria, the question arises as to how we should trade-off the measured pluses and minuses across the different alternatives.

How Do You Propose Addressing This Issue?

In general, there are a variety of multi-attribute evaluation methods to do this trade-off analysis. One well-developed tool is to convert all physical impacts into an estimated economic value, expressed in dollars. This is cost-benefit analysis. It thus reduces all outputs of an LCA to a single metric – $$ – by which all alternatives can be compared. Of course, there are enormous problems of data and methods with cost-benefit analysis, and one might reasonably despair of being able to generate anything meaningful after the uncertainty in physical LCA is compounded by uncertainty in cost-benefit analysis. Still, cost-benefit analysis can be provocative, or if not that at least entertaining, or if not that at least capable of keeping economists from more insidious activities.

PRIORITY 18

Increase Integration of Uncertainty During Environmental Life Cycle Evaluations

Originators:

Rice on behalf of himself and Wang

The following issues were consolidated under the following title:

Title: **Integration of Uncertainty in Environmental Life Cycle Evaluations**

Originator: Rice

Issue Description:

We will always be making fuel decisions under uncertainty. Understanding the life cycle trade-offs associated with fuels choices requires a good understanding of the uncertainty in various possible outcomes.

Importance:

The uncertainties associated with evaluating fuel options fall into several categories:

- Scientific judgments when evidence is contradictory and the cause is unknown.
- Mis-specified models (e.g., incomplete physical knowledge, "fudge factors").
- Statistical uncertainties (e.g., population distributions, range, bounds).
- Value systems (e.g., different views of nature, long-range land use planning).

Techniques are needed to better incorporate different measures of uncertainty into integrated modeling approaches. These approaches will aid decision makers to perform sensitivity analysis to set priorities regarding actions needed to reduce key uncertainties.

How Do You Propose Addressing This Issue?

Approaches to integrate different measures of uncertainty into modeling have been developed. These approaches need to be applied to life cycle evaluations associated with fuel choices. Dr. Paolo Ricci of the University of San Francisco would be a good person to begin applying these approaches to fuels environmental trade-offs. Susan Powers of Clarkson University has also been considering methods to incorporate uncertainty into fuel choices.

Title: **Credible Life Cycle Assessments Need to Be Transparent with Uncertainties Addressed**

Originator: Wang

Issue Description:

LCAs need to be transparent in order to present system boundaries, data sources, and assumptions in a clear way so that readers can understand what is behind the results. LCAs need to address uncertainties in a systematic way. LCA users often expect point-estimate results. But, the reality is that there are many uncertainties involved in technologies, especially the technologies for the future. On the other hand, results from different studies may show larger uncertainties than they actually are because underlying system boundaries and methodologies are different among studies. The uncertainties induced by different system boundaries and methodologies need to be sorted out and eliminated.

Importance:

Because of less transparency of studies, LCA users are often confused. Transparency of LCAs will help users better understand the results.

Uncertainties with LCA results are part of the reality. A better way is needed to convene LCA results to policy makers and politicians; however, uncertainties need to be addressed in scientific ways.

How Do You Propose Addressing This Issue?

Good scientific analysis.

PRIORITY 19

Set Priorities for Improving Life Cycle Assessments of Fuel Options

Originator:

Lave

Issue Description:

An LCA has two major problems. The first is the lack of data concerning inputs and discharges for the production processes throughout the U.S. economy. An LCA, by definition, requires an examination of all supporting processes. The U.S. has made major progress since 1970 in reporting pollution discharges, principally through the Toxic Release Inventory (TRI). Unfortunately, most air and water pollutant releases are still not publicly available data. For example, the USEPA's Aerometric Information Retrieval System database reports "pollution factor" data, not actual emissions, even though the latter are usually available. If anything, the conventional air and water pollution data are less sensitive and convey less potentially proprietary information than the TRI data. More compressive discharge data are needed.

The second major problem is getting beyond the life cycle inventory stage. The Green Design Initiative group at Carnegie Mellon University has developed models that give first-order approximations. For example, our Carnegie Mellon University Environmental Toxicity (CMU-ET) model uses Occupational Safety and Health Administration (OSHA) Threshold Limit Values to weight environmental discharges. We found that unweighted TRI emissions put a focus on chemical plants, while weighted TRI emissions shifted the focus to battery and other metals plants.

Importance:

Getting beyond these first-order approximations is difficult. Estimating health and environmental impacts poses formidable difficulties. We will not make progress until we decide which effects are most important: is it health (chronic or acute), ecology, or aesthetics? We need to narrow the range of issues and pollutants. The area needs a major research program, but there must be an agenda that focuses the research tightly.

How Do You Propose Addressing This Issue?

The USEPA and state agencies should declare that an LCA approach will be the foundation of their analyses and regulations. They should then commit to developing discharge databases that will improve the LCA inventory analysis for indirect impacts.

We should make greater use of first-order impact models, such as CMU-ET, as immediately available methods for LCA impact assessment.

USEPA and state agencies must support a research program to assess the impacts of pollution discharges. This program requires careful study to lay out a tight agenda and to manage the program to keep it tightly focused on answering the most important questions for LCA impact assessment.

PRIORITY 20

Separate Political from Scientific Issues; Recognize That There Are Competing Priorities for Which Life Cycle Assessments Will Be Used

Originators:

Adler on behalf of herself, Kneiss, and Williams

The following issues were consolidated under the above title:

Title: **Separate Political from Scientific Issues; Recognize That There Are Competing Priorities for Which Life Cycle Assessment Will Be Used**

Originator: Adler

Issue Description:

There is a need for analysts to provide the sound scientific basis for a wide range of assessment and policy needs. This science is much more useful when positions and politics are not assumed.

Importance:

This is a key point if an LCA is to become an accepted policy-making tool. Positions and opinions will certainly come into play as policies are developed. It is detrimental and inappropriate to include them in the supporting science.

How Do You Propose Addressing This Issue?

Keep an open mind when developing the LCA tools that we need to support future fuel policy development.

Title: **Science Versus Policy: Sound Scientific Assessments Should Not Be Outpaced by Expeditious Policy Decisions**

Originator: Kneiss

Issue Description:

Scientifically based LCAs are time-consuming, requiring the development of methodologies, collection of meaningful data, and conducting and peer-reviewing the assessments themselves. Such an extensive process often conflicts with the need for policy decisions that are desired *now* and, unfortunately, are often based on public perceptions influenced by media portrayals of the issues. The purpose of an LCA is to provide sound, comprehensive information to help perform broader analyses (cost-benefits) and to establish policy.

Importance:

In conducting an LCA, we must recognize the value it brings to the broader management of fuel issues. The ways in which the LCA process and outcomes are communicated to policy makers, in advance of and during the debates on what we should be doing to improve fuel and energy policy, should be primary considerations. Failure to do so leaves the LCA to a secondary role as an interesting "academic exercise," but ineffective to help derive fuels policy. This is not a desired goal for conducting and using LCAs.

How Do You Propose Addressing This Issue?

Each of us has an important role in educating and communicating why LCAs are important, why they are difficult and time-consuming to conduct, and how they can (and should) be incorporated into policy decisions.

Title: **The Debate over Alternative Fuels Should Be Driven More by Scientific Data Than by Public Perceptions**

Originator: Williams

Issue Description:

When conducting an LCA, one of the first tasks is to identify the appropriate model parameters and system boundaries. Extensive efforts are then taken to collect/generate data for each of these parameters. Given the time and resources involved, along with the important role each of these parameters has on the final results, these efforts should focus more on "real" issues and

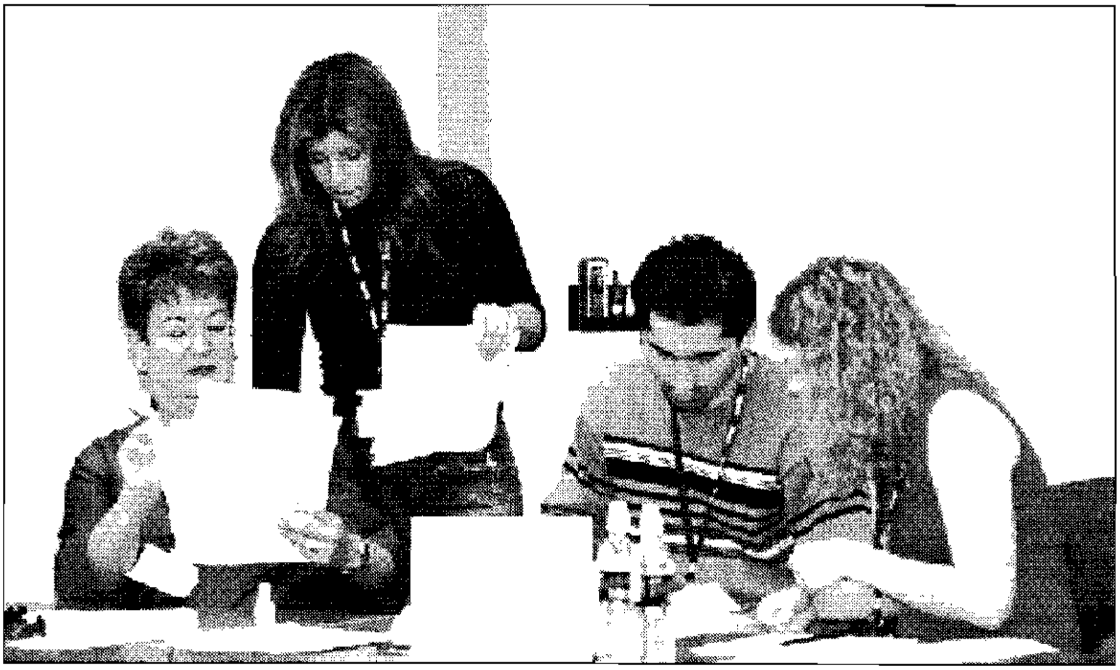
"realistic" scenarios, rather than "perceived" issues and "worst case" scenarios. That is, an LCA may be misguided or yield unrealistic results if the majority of research attention is given to insignificant or unlikely events or if upper-bound values are used to represent the lack of knowledge about certain "perceived" parameters. For example, although it is commonly believed that MTBE poses a significant risk to drinking-water supplies, these claims are not necessarily supported by the available monitoring data, particularly in California. The intense focus on this single (perceived) issue may, therefore, detract from the broader assessment that should be conducted in MTBE and other fuels in terms of their entire life cycle impacts.

Importance:

The issue of putting "perceived" impacts into their proper context and looking at the "full picture" is extremely important if an LCA is to be considered an objective evaluation of different alternatives. (While consideration of public values is important, it is also important to ensure that these values are based on an informed public, rather than on misleading data, media hype, or other misperceptions.)

How Do You Propose Addressing This Issue?

Ways to address this issue for alternative fuels would be to have broad stakeholder involvement and external peer-review when designing and conducting an LCA and to ensure that the focus remains on "real" issues that are supported by data, rather than "perceived" issues.



PRIORITY 21

Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment

Originator:

Carter

Issue Description:

Many of the worst environmental impacts of emissions or releases are due to chemical reactions. For example, photochemical air pollution involves a highly complex sequence of reactions of emitted VOCs in the presence of NO_x. This complexity requires use of computer models to predict the effects of emissions on air quality impacts, such as the formation of ozone and other manifestations of photochemical smog. These models incorporate chemical mechanisms for many compounds that have many uncertainties and whose predictive capabilities may have not been experimentally verified in some cases. If the chemical mechanisms used in the model to represent the reactions of these pollutants are incorrect, the model predictions will also be incorrect.

The predictive capabilities of the chemical mechanisms of the major classes of compounds known to be important in major types of current vehicle fuels have been reasonably well established, at least for relatively high NO_x conditions characteristic of polluted urban centers; however, the predictive capabilities of the mechanisms are less well evaluated under low NO_x or long-range transport conditions that may affect air-quality predictions.

In addition, it is possible that a complete LCA may indicate signifieant emissions of a type of compound that has not been adequately studied. In this case, kinetic, mechanistic, and environmental chamber studies on the compound may be necessary to assess the effects of its emissions on air quality and to assess its overall environmental fate.

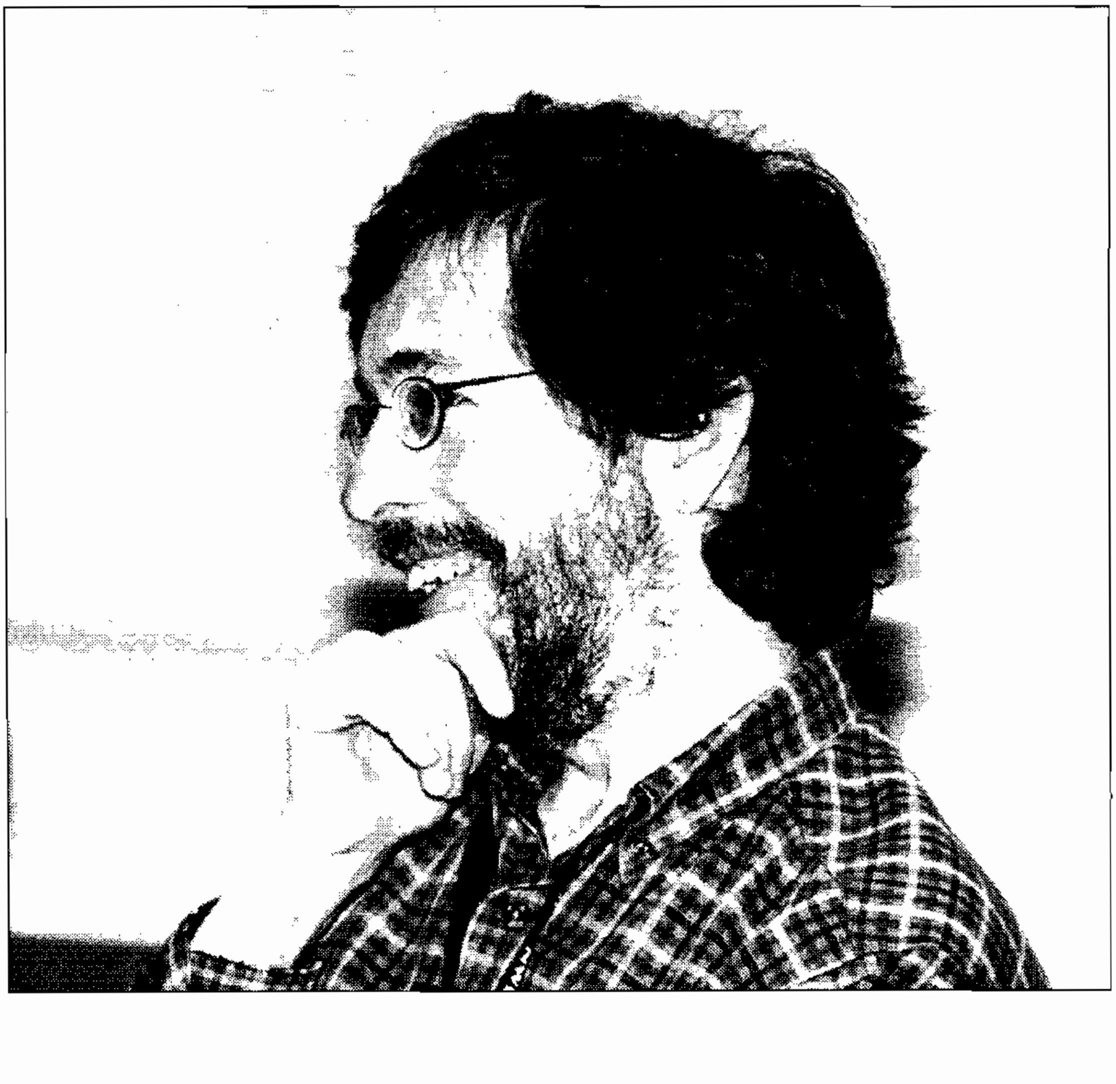
Importance:

Appropriate chemical mechanisms are essential to accurately predict the effects of emissions on the formation of secondary pollutants, such as ozone or other oxidants formed in the atmosphere, and to assess the ultimate environmental fate of the pollutants; however, many of the most important compounds, such as the major components of current gasoline and the major alternative fuel compounds (e.g., methanol, ethanol, MTBE, etc.,) have already been extensively studied, at least under high NO_x conditions. But, if new research results in identifying

compounds that have not been studied, then the importance of this research will increasc. Otherwise, the priority for additional work in this area will depend on assessing the remaining uncertainties in the current mechanisms on long-range transport and ultimate environmental fate.

How Do You Propose Addressing This Issue?

Measurements of relevant reaction rate constants are essential because they determine how rapidly the compounds react in the atmosphere. Mechanistic and product studies are necessary to determine how the reactions affect secondary pollutants and to determine the environmental fate of the compound in the atmosphere. A number of laboratories have established track records in this area. Environmental chamber experiments are necessary to evaluate the predictive capabilities of the mechanisms, and mechanism development and modeling studies of the chamber experiments are necessary to incorporate the results into air-quality models. We are developing a new environmental chamber facility at our laboratories that are capable of evaluating mechanisms under low NO_x and longer-range transport conditions than have previously been possible.



PRIORITY 22

Consider Land Use and Soil Health in Life Cycle Analyses

Originator:

Sheehan

Issue Description:

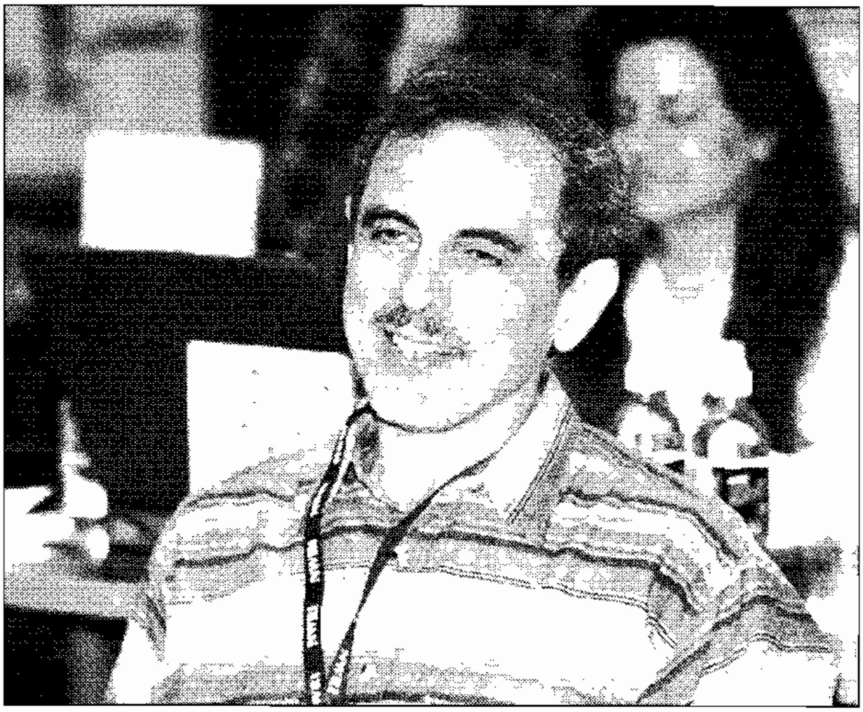
To date, all life cycle analyses assume that land is a neutral player in our fuel choices. This is simply wrong. For example, we are potentially ignoring one of the greatest effects of producing and using biofuels.

Importance:

It goes without saying that land itself is a critical natural resource. Land impacts may well be the Achilles' heel of biofuels. Likewise, soil is an irreplaceable resource. Damage to soil health can directly impact our ability to provide food for a growing population. Soil is also a key player in the natural carbon cycle. As such, how soil responds to agricultural practices can be the determining factor for a fuel's contribution to greenhouse gas emissions.

How Do You Propose Addressing This Issue?

Soil scientists and ecologists need to be a part of the multidisciplinary effort to understand the impacts of fuel choices.



PRIORITY 23

Recognize Differences between Complex and Predictive Models and the Inconsistencies in Regulatory Models

Originator:

Andress

Issue Description:

The emission response curves of the complex and predictive models for some pollutants are inconsistent. For example, the predictive model estimates NO_x emissions increase as the oxygen content of the fuel increases, while the complex model estimates they decrease. Conversely, the predictive model estimates a much greater decrease in exhaust VOCs than the complex model. A fundamental difference exists in the way the two models estimate emission changes. The complex model measures changes in terms of raw mass emissions, while the predictive model applies reactivity weighting factors to evaporative VOC emissions and potency weights to toxic air pollutants.

Importance:

A NRC report concluded that these differences indicate one or both models is producing incorrect results. The accuracy of an emissions model for alternative fuel formulations has a fundamental effect on ambient air quality. Since these are regulatory compliance models, their response function behavior has a direct impact on gasoline produceability and economics.

How Do You Propose Addressing This Issue?

- Assemble a panel of independent experts, including representatives from the CalEPA, USEPA, USDOE, scientists, consultants, etc.

- Consider forming the panel under an independent agent and provide adequate funding.

- Incorporate public participation.

- Provide adequate support staff to carry out statistical analyses recommended by the panel.

PRIORITY 24

Develop an Environmental Life Cycle Evaluation of Fuel Options to Inform the Regulatory Process

Originator:

Smith

Issue Description:

Federal, state, and local environmental protection regulations for fuels consist of a "patchwork" of tools that are based on clean up or pollution prevention, rather than on a holistic, life cycle approach. These regulations do not anticipate future technologies and are primarily medium-specific (i.e., air, water, soil/sediment, tissue).

Importance:

To engender creativity in the development of new technologies and their applications, it is important to have a regulatory framework that supports innovation. The life cycle approach can be used as a framework to identify and relate the various federal, state, and local regulations so as to develop a more holistic picture and ensure an environmental "safety net."

How Do You Propose Addressing This Issue?

Pull together attorneys, LCA practitioners, the regulatory community, and other stakeholders to construct the "quilt" from the "patches."

STRENGTH OF FEELING ANALYSES OF PARTICIPANTS AND SUBGROUPS OF PARTICIPANTS

The idea behind the Strength-of-Feeling Analysis is that priority ranking alone does not show unanimity, or lack of unanimity, by the workshop participants. Strength-of-Feeling Analysis, however, provides a transparent quantitative measure of agreement or disagreement among all participants, and subgroups of participants. Any category of participant that represents two or more individuals (that way no individual's ranking is revealed) can be analyzed. In this workshop, four participant subgroups were formed: consultants, industry representatives, regulators, and researchers (academic and governmental). Table 1 shows how the 35 participants ranked all 24 major issue areas. Tables 2 through 5 show how the subgroups ranked the major issue areas.

Looking at the priorities within each of the subgroup tables some stark differences can be seen. For example, the 15 consultants and industry participants were nearly unanimous in their agreement on the two highest priority issue areas (Tables 2 and 3). The 12 researchers (Table 5) agreed with the consultants and industry participants on their highest priority issue but placed the second down in position number 11. Regulators (Table 4) placed the two highest ranked issues chosen by the consultants and industry participants as their 5th and 8th priorities. These differences in perception of the importance of particular major issue areas by subgroups explain why the overall agreement in Table 1 was so low.

TABLE 1

Issues (24) Ranked by All Participants (35)

Rank	Title	Times Picked/Pts	Strength of Feeling
1.	Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries	28/188	53.7%
2.	Fully Identify and Quantify Environmental Release Points in Fuel Transport, Storage, and Handling Infrastructures	27/152	43.4%
3.	Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle	24/144	41.1%
4.	Include Net Energy Balances As a Part of Life Cycle Cousiderations	24/131	37.4%
5.	Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport	22/127	36.3%
6.	Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models	18/119	34.0%
7.	Ensure Better Communications between Scientists and Policy Makers	24/113	32.3%
8.	Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis	19/109	31.1%
9.	Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options	15/106	30.3%
10.	Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern	17/103	29.4%
11.	Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels	16/88	25.1%
12.	Define Downstream Socioeconomic Impacts of Manufacturing Choices	16/87	24.9%

Rank	Title	Times Picked/Pts	Strength of Feeling
13.	Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution, and Use of Various Biologically Based Fuel Options	15/77	22.0%
14.	Need Performance Criteria to Evaluate the Pollution Potential of Fuel Compounds to Define Their Attenuation in Environmental Media and the Effectiveness of Remediation, Control, and Treatment Technologies	12/61	17.4%
15.	Expand Air Emissions Analyses for Alternative Fuels Blended in Gasoline to Include Both Off-Road Gasoline Engines and Future Vehicle Benefits	9/54	15.4%
16.	Use Life Cycle Analyses As a Tool for Making Ethical and Political Choices in Support of Sustainable Development	9/40	11.4%
17.	Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses	8/36	10.3%
18.	Increase Integration of Uncertainty During Environmental Life Cycle Evaluations	9/35	10.0%
19.	Set Priorities for Improving Life Cycle Analyses of Fuel Options	7/34	9.7%
20.	Separate Political from Scientific Issues; Recognize That There Are Competing Priorities for Which Life Cycle Assessments Will Be Used	10/32	9.1%
21.	Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment	6/26	7.4%
22.	Consider Land Use and Soil Health in Life Cycle Analyses	5/25	7.1%
23.	Recognize Differences between Complex and Predictive Models and the Inconsistencies in Regulatory Models	4/22	6.3%
24.	Develop an Environmental Life Cycle Evaluation of Fuel Options to Inform the Regulatory Process	3/12	3.4%

TABLE 2

Issues (24) Ranked by Consultant Participants (11)

Rank	Title	Times Picked/Pts	Strength of Feeling
1.	Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries	10/71	64.5%
2.	Fully Identify and Quantify Environmental Release Points in Fuel Transport, Storage, and Handling Infrastructures	9/59	53.6%
3.	Include Net Energy Balances As a Part of Life Cycle Considerations	8/51	46.4%
4.	Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport	7/47	42.7%
5.	Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle	7/45	40.9%
6.	Define Downstream Socioeconomic Impacts of Manufacturing Choices	8/38	34.5%
7.	Expand Air Emissions Analyses for Alternative Fuels Blended in Gasoline to Include Both Off-Road Gasoline Engines and Future Vehicle Benefits	6/34	30.9%
8.	Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels	4/30	27.3%
9.	Need Performance Criteria to Evaluate the Pollution Potential of Fuel Compounds to Define Their Attenuation in Environmental Media and the Effectiveness of Remediation, Control, and Treatment Technologies	6/25	22.7%
10.	Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern	4/24	21.8%
11.	Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis	4/23	20.9%
12.	Ensure Better Communications between Scientists and Policy Makers	5/23	20.9%

Rank	Title	Times Picked/Pts	Strength of Feeling
13.	Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options	4/21	19.1%
14.	Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models	3/21	19.1%
15.	Recognize Differences between Complex and Predictive Models and the Inconsistencies in Regulatory Models	2/18	16.4%
16.	Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution, and Use of Various Biologically Based Fuel Options	5/18	16.4%
17.	Separate Political from Scientific Issues: Recognize That There Are Competing Priorities for Which Life Cycle Analyses Will Be Used	4/14	12.7%
18.	Consider Land Use and Soil Health in Life Cycle Analyses	2/12	10.9%
19.	Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment	2/9	8.2%
20.	Increase Integration of Uncertainty During Environmental Life Cycle Evaluations	2/7	6.4%
21.	Use Life Cycle Analyses As a Tool for Making Ethical and Political Choices in Support of Sustainable Development	3/5	4.5%
22.	Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses	1/4	3.6%
23.	Set Priorities for Improving Life Cycle Analyses of Fuel Options	2/4	3.6%
24.	Develop an Environmental Life Cycle Evaluation of Fuel Options to Inform the Regulatory Process	1/2	1.8%

TABLE 3

Issues (24) Ranked by Industry Participants (4)

Rank	Title	Times Picked/Pts	Strength of Feeling
1.	Fully Identify and Quantify Environmental Release Points in Fuel Transport, Storage, and Handling Infrastructures	4/29	72.5%
2.	Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries	4/26	65.0%
3.	Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options	3/26	65.0%
4.	Expand Air Emissions Analyses for Alternative Fuels Blended in Gasoline to Include Both Off-Road Gasoline Engines and Future Vehicle Benefits	3/20	50.0%
5.	Ensure Better Communications between Scientists and Policy Makers	3/18	45.0%
6.	Define Downstream Socioeconomic Impacts of Manufacturing Choices	2/15	37.5%
7.	Include Net Energy Balances As a Part of Life Cycle Considerations	4/15	37.5%
8.	Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis	3/13	32.5%
9.	Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle	2/10	25.0%
10.	Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern	3/10	25.0%
11.	Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses	2/10	25.0%
12.	Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport	2/8	20.0%
13.	Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models	1/8	20.0%

Rank	Title	Times Picked/Pts	Strength of Feeling
14.	Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment	1/4	10.0%
15.	Separate Political from Scientific Issues: Recognize That There Are Competing Priorities for Which Life Cycle Analyses Will Be Used	2/4	10.0%
16.	Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels	1/4	10.0%

TABLE 4

Issues (24) Ranked by Regulator Participants (8)

Rank	Title	Times Picked/Pts	Strength of Feeling
1.	Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle	5/43	61.4%
2.	Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern	5/36	51.4%
3.	Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport	6/35	50.0%
4.	Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options	4/35	50.0%
5.	Fully Identify and Quantify Environmental Release Points in Fuel Transport, Storage, and Handling Infrastructures	6/32	45.7%
6.	Ensure Better Communications between Scientists and Policy Makers	5/29	41.4%
7.	Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models	4/28	40.0%
8.	Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries	4/24	34.3%
9.	Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution and Use of Various Biologically Based Fuel Options	3/21	30.0%
10.	Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels	5/20	28.6%
11.	Include Net Energy Balances As a Part of Life Cycle Considerations	5/19	27.1%
12.	Define Downstream Socioeconomic Impacts of Manufacturing Choices	3/15	21.4%
13.	Formulate Specific Fuel Policies; Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis	4/13	18.6%

Rank	Title	Times Picked/Pts	Strength of Feeling
14.	Need Performance Criteria to Evaluate the Pollution Potential of Fuel Compounds to Define Their Attenuation in Environmental Media and the Effectiveness of Remediation, Control, and Treatment Technologies	2/7	10.0%
15.	Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment	1/6	8.6%
16.	Increase Integration of Uncertainty During Environmental Life Cycle Evaluations	2/5	7.1%
17.	Consider Land Use and Soil Health in Life Cycle Analyses	1/5	7.1%
18.	Use Life Cycle Analyses As a Tool for Making Ethical and Political Choices in Support of Sustainable Development	2/4	5.7%
19.	Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses	1/4	5.7%
20.	Set Priorities for Improving Life Cycle Analyses of Fuel Options	1/3	4.3%
21.	Recognize Differences between Complex and Predictive Models and the Inconsistencies in Regulatory Models	1/1	1.4%

TABLE 5

Issues (24) Ranked by Researcher Participants (12)

Rank	Title	Times Picked/Pts	Strength of Feeling
1.	Conduct a Timely Initial Assessment That Includes: Environmental, Economic, Consumer Acceptance, and Suitability to End-use Needs to Identify Critical Issues, Data Gaps, and Appropriate Boundaries	10/67	51.5%
2.	Develop Data and Information Systems to Support Fuel Life Cycle Environmental Impact Assessments and Comprehensive Multimedia Models	10/62	47.7%
3.	Formulate Specific Fuel Policies: Compare the World with and without the Policy; Use Economic-Engineering Models to Do the Analysis	8/60	46.2%
4.	Assess Acute/Chronic Health Risks Associated with Key Primary Emissions and Secondary Byproducts of Fuels throughout the Life Cycle	9/46	35.4%
5.	Include Net Energy Balances As a Part of Life Cycle Considerations	7/46	35.4%
6.	Ensure Better Communications between Scientists and Policy Makers	11/43	33.1%
7.	Determine Direct and Indirect Impacts to Ecosystems and Ecologic Receptors from the Production, Distribution and Use of Various Biologically Based Fuel Options	7/38	29.2%
8.	Identify Potentially Problematic Fuel Components, Byproducts, and Impurities; Address Knowledge Gaps Regarding Their Environmental Analyses, Persistence, and Fate and Transport	7/37	28.5%
9.	Define Water Quality Impacts Associated with the Life Cycles of Alternative Fuels	6/34	26.2%
10.	Stress the Importance of Goal and Scope Definition and tbe Availability of Representative Data to Determine the Impacts of Concern	5/33	25.4%
11.	Stress the Importance of Goal and Scope Definition and the Availability of Representative Data to Determine the Impacts of Concern	8/32	24.6%
12.	Use Life Cycle Analyses As a Tool for Making Ethical and Political Choices in Support of Sustainable Development	4/31	23.8%

Rank	Title	Times Picked/Pts	Strength of Feeling
13.	Need Performance Criteria to Evaluate the Pollution Potential of Fuel Compounds to Define Their Attenuation in Environmental Media and the Effectiveness of Remediation, Control, and Treatment Technologies	4/29	22.3%
14.	Set Priorities for Improving Life Cycle Analyses of Fuel Options	4/27	20.8%
15.	Develop a Life Cycle Evaluation and Testing Matrix to Quickly and Consistently Evaluate Transportation Fuel Options	4/24	18.5%
16.	Increase Integration of Uncertainty During Environmental Life Cycle Evaluations	5/23	17.7%
17.	Define Downstream Socioeconomic Impacts of Manufacturing Choices	3/19	14.6%
18.	Consider Incorporating Life Cycle Analyses into Larger Comprehensive Cost-Benefit Analyses	4/18	13.8%
19.	Separate Political from Scientific Issues; Recognize That There Are Competing Priorities for Which Life Cycle Analyses Will Be Used	4/14	10.8%
20.	Develop an Environmental Life Cycle Evaluation of Fuel Options to Inform the Regulatory Process	2/10	7.7%
21.	Consider Land Use and Soil Health in Life Cycle Analyses	2/8	6.2%
22.	Evaluate the Reaction Mechanisms Used in Models to Predict the Effects of Emissions or Releases into the Environment	2/7	5.4%
23.	Recognize Differences between Complex and Predictive Models and the Inconsistencies in Regulatory Models	1/3	2.3%

APPENDICES

APPENDIX A

ACRONYMS

API	American Petroleum Institute
ATSDR	Agency for Toxic Substance and Disease Registry
BTEX	benzene, toluene, ethylbenzene, xylene (o-, m-, p-xylene)
BTU	British Thermal Unit
CAAA90	1990 Clean Air Act Amendments
CalEPA	(State of) California Environmental Protection Agency
CAFÉ	(NAS) Corporate Averaged Fuel Economy (Report)
CARB	California Air Resources Board
CDHS	California Department of Health Services
CE-CERT	College of Engineering Center for Environmental Research and Technology (University of California, Riverside)
CMU	Carnegie Mellon University
CMU-ET	Carnegie Mellon University Environmental Toxicity (Model)
EGRID	USEPA air emissions database for utilities
FGT & PI	Fiber Glass Tank and Pipe Institute
EV	electric vehicle
GEIMS	Geographic Environmental Information Management System
GMO	genetically modified organisms
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
HHV	high heat value
HTML	hyper text markup language
ISO	International Standards Organization
LCA	life cycle assessment
LCI	life cycle inventory
LHV	low heat value
LLNL	Lawrence Livermore National Laboratory
LUST	leaking underground storage tank
MTSHI	manufacturing, transport, storage, and handling infrastructure
MTBE	methyl tertiary butyl ether

NACE	National Association of Corrosion Engineers
NAS	National Academy of Sciences
NIEHS	National Institute of Environmental Health Service
NO_x	nitrogen oxide
NRC	National Resource Council
OAR	Office of Air and Radiation (USEPA)
OGWDN	Office of Groundwater and Drinking Water (USEPA)
ORD	Office of Research and Development (USEPA)
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response (USEPA)
OUST	Office of Underground Storage Tanks (USEPA)
PAN	peroxyacetyl nitrate
PEI	Petroleum Equipment Institute
Ppb	parts per billion
QA/QC	quality assurance/quality control
RFG	reformulated gasoline
RVP	Reid vapor pressure
SETAC/UNEP	Society of Environmental Toxicology and Chemistry/United Nations Environment Programme
SIP	State Implementation Plan
STI	Steel Tank Institute
SWOT	Strengths, Weaknesses, Opportunities, and Threats (Analysis)
SWRCB	State Water Resources Control Board
TBA	tertiary-butyl alcohol
TNRCC	Texas Natural Resource Conservation Commission
TRI	toxic release inventory
TRV	toxicity reference values
TSCA	Toxic Substances Control Act
ULEV	ultra-low emission vehicles
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USGS	United States Geological Survey
UST	underground storage tanks
VOC	volatile organic compound
WSPA	Western States Petroleum Association

APPENDIX B

PREVIOUS NGT WORKSHOPS CONDUCTED BY NWRI

Issues in Methanol Research. Report of a workshop sponsored by NWRI in cooperation with the American Methanol Institute. Hilton Hotel, Costa Mesa, CA, October 5-7, 2001. 173 p.

Chino Basin Organics Management. Report of a workshop sponsored by NWRI in cooperation with the Inland Empire Utilities Agency, and the Southern California Alliance of Publicly Owned Treatment Plants. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, April 18-20, 2001. NWRI-01-03, 205 p.

Desalination Research & Development. Report of a workshop sponsored by NWRI in cooperation with the United States Bureau of Reclamation. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, January 19-21, 2001. 185p.

Knowledge Management. Report of a workshop sponsored by NWRI. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA January 5-7, 2001. 169 p.

Oxygenate Contamination. Report of a workshop sponsored by NWRI in cooperation with the United States Bureau of Reclamation. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 15-17, 2001: 258p.

Utility Leadership. Report of a workshop sponsored by NWRI in cooperation with Malcolm Pirnie, Inc., the University of Southern California, and the University of South Florida. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, October 24-26, 1999: 154p.

Non-potable Water Recycling. Report of a workshop sponsored by NWRI in cooperation with Irvine Ranch Water District and the Orange County Water District. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, May 23-25, 1999: 174p.

Conjunctive Use Water Management Program. Report of a workshop jointly sponsored by NWRI, Association of Ground Water Agencies, and the Metropolitan Water District of Southern California. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, May 27-29, 1998: 157p.

Barriers to Providing Safe Drinking Water Through Small Systems. Report of a workshop jointly sponsored by NWRI, Pan American Health Organization, and NSF International/WHO Collaborative Center. Pan American Health Organization Headquarters, Washington, D.C., May 13-15, 1998: English report: 175p., Spanish report: 188p. (Bound in a single volume.)

Barriers to Harvesting Stormwater. Report of a workshop jointly sponsored by NWRI, Los Angeles County Department of Public Works, County of Orange Public Facilities & Resources Department, Southern California Coastal Water Project, and the American Oceans Campaign.

Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, September 22-24, 1997: 159p.

Groundwater Disinfection Regulations Benefits Conference. Report of a conference sponsored by NWRI. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, March 17, 1997: 75p.

Groundwater Disinfection Regulation. Report of a workshop jointly sponsored by NWRI and the USEPA. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, January 6-8, 1997: 209p.

Membrane Biofouling. Report of a workshop jointly sponsored by NWRI, UNESCO Centre for Membrane Science and Technology, and CRC for Waste Management and Pollution Control, LTD. UNSW Institute of Administration, Sydney, Australia, November 15-17, 1996: 176p.

The Santa Ana River Watershed. Report of a workshop jointly sponsored NWRI and the Santa Ana Watershed Project Authority. Co-sponsors included: City of San Bernardino Water Department, City of Riverside, Western Municipal Water District, and Orange County Water District. Kellogg West Conference Center/Hotel, California State Polytechnic University, Pomona, CA, August 23-25, 1995: 182p.

The New River. Report of a workshop jointly sponsored by NWRI and the County of Imperial, California. Barbara Worth Country Club, Holtville, CA, May 19-21, 1995: English report: 134p., Spanish report: 134p. (Bound in a single volume)

Establishment of The Middle-East Water and Energy Research and Technology Centre. Report of a workshop jointly sponsored by NWRI and the Sultanate of Oman through the Worldwide Desalination Research and Technology Survey. Muscat, Oman: September 21, 1994: 29p.

Risk Reduction in Drinking Water Distribution Systems. Report of a workshop jointly sponsored by NWRI and the Environmental Criteria and Assessment Office of the USEPA. Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, Irvine, CA, February 27-28, 1994: 142p.

Fouling and Module Design. Report of a workshop jointly sponsored by NWRI and the National Science Foundation (NSF). Virden Conference Center of the University of Delaware, Lewes, DE, October 30 – November 1, 1993: 115p.

Groundwater Disinfection Rule. Report of a workshop jointly sponsored by NWRI and the USEPA in collaboration with the Weston Institute. Virden Conference Center of the University of Delaware, Lewes, DE. June 7-8, 1992: 103p

APPENDIX C

PARTICIPANTS' ADDRESS LIST

Deborah Adler
Environmental Scientist
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
2565 Plymouth Road
Ann Arbor, MI 48105
(734) 214-4223
(734) 214-4573 Fax
adler.deborah@epa.gov

Pedro J.J. Alvarez, Ph.D., P.E., D.E.E
Professor
University of Iowa
Department of Civil and Environmental Engineering
4119 Seaman's Center
Iowa City, IA 52242-1527
(319) 335-5065
(319) 335-5660 Fax
pedro-alvarez@uiowa.edu

David Andress
President
David Andress & Associates
11008 Harriet Lane
Kensington, MD 20895
(301) 933-7179
(301) 933-7189 Fax
david.Andres@eia.doe.gov

William P.L. Carter, Ph.D.
Research Chemist
CE-CERT University of California
Riverside, CA 92521
(909) 781-5797
(909) 781-5790 Fax
carter@cert.ucr.edu

Mary Ann Curran
LCA Research Manager
U.S. Environmental Protection Agency
Office of Research and Development
26 W. Martin Luther King Drive MS-466
Cincinnati, OH 45268
(513) 569-7782
(513) 569-7111 Fax
curran.maryann@epa.gov

James M. Davidson, P.G.
President
Alpine Environmental, Inc.
203 West Myrtle Street, Suite C
Fort Collins, CO 80521
(970) 224-4608
(970) 224-2329 Fax
jdavidsonalpine@cs.com

J. Michael Davis, Ph.D.
U.S. Environmental Protection Agency
Office of Research and Development
National Center For Environmental Assessment MD-52
Research Triangle Park, NC 27711
(919) 541-4162
(919) 541-0245 Fax
davis.jmichael@epamail.epa.gov

Rula A. Deeb, Ph.D.
Senior Project Engineer
Bioremediation Specialist
Malcolm Pirnie, Inc.
2000 Powell Street, Suite 1180
Emeryville, CA 94608
(510) 596-3060 Office
(510) 735-3005 Direct
(510) 596-8855 Fax
rdeeb@pirnie.com

Mark A. Delucchi, Ph.D.
Research Scientist
University of California, Davis
5029 Vista Del Oro Way
Fair Oaks, CA 95628
(916) 989-5566
(916) 989-5566 Fax
madelucchi@ucdavis.edu

Brendan P. Dooher, Ph.D.
Lawrence Livermore National Laboratory
7000 East Avenue, #L-542
P.O. Box 808, L-542
Livermore, CA 94551
(925) 423-1359
(925) 422-2095 Fax
dooher1@llnl.gov

Donna Drogos, P.E.
Supervising Hazardous Materials Specialist
Alameda County Environmental Health
1131 Harbor Bay Parkway
Alameda, CA 94502-6577
(510) 567-6721 Office
(510) 393-1457 Cell
(510) 337-9335 Fax
ddrogos@pacbell.net

Stanley Durkee
Mobile Source Issues
U.S. Environmental Protection Agency
Office of Science Policy, MC-8105
Washington, DC 20460
(202) 564-6784
(202) 565-2715 Fax
durkee.stan@epa.gov

Glenn B. Giacobbe
Business Development Director for
Oxygenated Fuels
Lyondell Chemical Co.
1221 McKinney Street
Houston, TX 77010
(713) 309-2064
(713) 951-1602 Fax
glenn.giacobbe@lyondell.com

Rick Handley
Director
Coalition of Northeaster Governors Policy
Research Center
Northeast Regional Biomass Program
400 N. Capitol Street, NE, Suite 382
Washington, DC 20001
(202) 624-8454
(202) 624-8463 Fax
rhandley@capital.net

Cal Hodge
President
A 2nd Opinion, Inc.
4606 FM 1960 West, Suite 400
Houston, TX 77069-4615
(281) 586-2213 Office
(281) 844-4162 Cell
(281) 586-2214 Fax
A2ndOpinionInc@aol.com

Michael E. Honeycutt, Ph.D.
Senior Toxicologist
Texas Natural Resource Conservation
Commission
P.O. Box 13087 MC-168
Austin, TX 78711-3087
(512) 239-1793
(512) 239-1794 Fax
mhoneycu@tnrcc.state.tx.us

John J. Kneiss
Vice President Regulatory & Technical
Affairs
Oxygenated Fuels Association
1401 New York Avenue, NW, Suite 520
Washington, DC 20005
(202) 393-6190
(202) 393-6199 Fax
jkneiss@bellatlantic.net

Jeff A. Kuhn
Chairman, MTBE & Fuel Oxygenates Work Group
2016 Choteau Street
Helena, MT 59601
(406) 444-5976
(406) 444-1901 Fax
jkuhn@state.mt.us

Lester B. Lave, Ph. D.
Carnegie Mellon University
Green Design Initiative
5000 Forbes Avenue
Pittsburgh, PA 15213-3890
(412) 268-8837
LL01@andrew.cmu.edu

David W. Layton, Ph.D.
Division Leader
Health and Ecological Assessment Division
Lawrence Livermore National Laboratory
7000 East Avenue, #L-286
Livermore, CA 94550
(925) 422-0918
(925) 423-6785 Fax
layton1@llnl.gov

Heather L. MacLean, Ph.D.
Assistant Professor
University of Toronto
Department of Civil Engineering
35 St. George Street
Toronto, Ontario M5S 1A4
Canada
(416) 946-5056
(416) 978-3674
hmaclean@ecf.utoronto.ca

Jeffrey Moller
Partner
Blank, Rome, Comisky & McCauley
One Logan Square
Philadelphia, PA 19103-6998
(215) 569-5792
(215) 569-5694 Fax
moller@blankrome.com

William J. Piel
Business Director
TEIR Associates, Inc.
160 Hidden Hills Road
Media, PA 19063
(610) 359-5728
(209) 671-8126 Fax
William.piel@teira.com

Susan E. Powers, Ph.D.
Associate Professor
Clarkson University
8 Clarkson Avenue
Potsdam, NY 13699-5710
(315) 268-6542
(315) 268-7985 Fax
sep@clarkson.edu

Robert E. Reynolds
President
Downstream Alternatives, Inc.
P.O. Box 2587
South Bend, IN 46680-2587
(219) 231-8974
(219) 231-8975
reynoldsatdai@compuserve.com

David W. Rice, Jr.
Environmental Chemistry & Biology Group Leader
Lawrence Livermore National Laboratory
P.O. Box 808, L-528
Livermore, CA 94551
(925) 423-5059
(925) 423-2095 Fax
rice4@llnl.gov

Andrew G. Salmon, Ph.D.
Chief Air Toxicology and Risk Assessment Unit
California Environmental Protection Agency
Office of Environmental Health Hazard Assessment
1515 Clay Street, 16th Floor
Oakland, CA 94612
(510) 622-3191
(510) 622-3210 Fax
asalmon@oehha.ca.gov

John Sheehan
Senior Research Engineer
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
(303) 384-6136
(303) 384-6877 Fax
john_Sheehan@nrel.gov

John Shipinski, Ph.D.
Senior Principal Engineer
Toyota Technical Center U.S.A.
1588 Woodridge
Ann Arbor, MI 48105
(734) 995-3754
(734) 995-5971 Fax
shipinski@ttc-usa.com

Timothy J. Skone, P.E.
Environmental Engineer
Science Applications International Corporation (SAIC)
11251 Roger Bacon Drive
Reston, VA 20190
(703) 736-0826
(703) 318-4604 Fax
SkoneT@SAIC.com

Barbara M. (Bobbye) Smith, Ph.D.
Regional Science Liaison
U.S. Environmental Protection Agency
Region 9/PMD-1
75 Hawthorne Street
San Francisco, CA 94105
(415) 972-3735
(415) 947-3558 Fax
smith.bobbye@epamail.epa.gov

Michael Q. Wang, Ph.D.
Environmental Analyst
Argonne National Laboratory
9700 S. Cass Avenue, Bldg. 362, Room B215
Argonne, IL 60439
(630) 252-2819
(630) 252-3443 Fax
mqwant@anl.gov

Walter J. Weber, Jr., Ph.D., P.E., D.E.E.
Gordon Maskew Fair and Earnest Boyce Distinguished University Professor
University of Michigan
Departments of Civil & Environmental Engineering and Chemical Engineering
1321 Beal/181 EWRE Building
Ann Arbor, MI 48103-2125
(734) 763-2274
(734) 936-4391 Fax
wjwjr@engin.umich.edu

James S. White
Principal
White Environmental Associates
428 E. Stone Canyon Way
Brea, CA 92821-2648
(714) 529-0652
(714) 529-3679 Fax
weajsw@aol.com

Pamela R.D. Williams, Sc.D.
Senior Scientist
Exponent
4940 Pearl East Circle, Ste. 300
Boulder, CO 80301
(303) 444-7270
(303) 444-7528 Fax
pwilliams@exponent.com

NWRI WORKSHOP STAFF

William S. Gaither, Ph.D., P.E.
Workshop Facilitator
Gaither & Associates
3601 Baring Street
Philadelphia, PA 19104
(215) 386-6800
(215) 386-3165 Fax
gaitherws@earthlink.net

Patricia Linsky
Editor
476 Esther Street
Costa Mesa, CA 92627
(949) 650-3431
(949) 650-3681 Fax
rblinsky@earthlink.net

Ronald B. Linsky
Executive Director
National Water Research Institute
10500 Ellis Avenue
Fountain Valley, CA 92708
(714) 378-3278
(714) 378-3375 Fax
NWRI-1@worldnet.att.net

Stephen R. Lyon, Ph.D.
Technical Information Specialist
Orange County Water District
10500 Ellis Avenue
Fountain Valley, CA 92708
(714) 378-3200
(714) 378-3375 Fax
slyon@ocwd.com

Gina Melin
Editor
National Water Research Institute
10500 Ellis Avenue
Fountain Valley, CA 92708
(714) 378-3278
(714) 378-3375 Fax
NWRI-4@worldnet.att.net

Joseph Pezely
Industrial Designer
Business Proposals/Corporate Graphics
728 Bent Lane
Newark, DE 19711
(302) 368-5931

Tammy Russo
Administrative Assistant/
Workshop Coordinator
National Water Research Institute
10500 Ellis Avenue
Fountain Valley, CA 92708
(714) 378-3278
(714) 378-3375 Fax
NWRI-2@worldnet.att.net

Teresa Taylor
Photographer
T. Taylor Photography
23010 Lake Forest Drive, Suite D-401
Laguna Hills, CA 92653
(949) 461-0606
(949) 461-0688 Fax
www.ttaylorphoto.com

Vahak Vartanian
Assistant
National Water Research Institute
10500 Ellis Avenue
Fountain Valley, CA 92708
(714) 378-3278
(714) 378-3375 Fax

APPENDIX D

PARTICIPANTS' BIOGRAPHICAL SKETCHES

Deborah Adler
Environmental Scientist, Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Debby Adler is an Environmental Scientist in the Advanced Technology Division of the National Vehicle and Fuel Emission Lab within the Office of Transportation and Air Quality for the U.S. Environmental Protection Agency. She has been employed by the U.S. Environmental Protection Agency since 1986, working primarily in the areas of alternative fuels, greenhouse gas emissions, and life cycle analyses of fuels. Her work supports the research, development, and analyses of national fuel policies. She leads the U.S. Environmental Protection Agency's Alternative Fuels Team and is the U.S. Environmental Protection Agency's representative to the Transportation Research Board Alternative Fuels Committee. Adler received both a B.S. in Atmospheric and Oceanic Science and an M.S. in Physical Oceanography from the University of Michigan.

Pedro J. J. Alvarez, Ph.D., P.E., D.E.E.
Professor, Civil and Environmental Engineering
University of Iowa

Pedro Alvarez has taught at the University of Iowa since 1993, focusing on the applications and implications of biological treatment processes in environmental engineering. His research interests include the bioremediation of contaminated aquifers, fate and transport of hazardous substances, and treatment of contaminated soil, water, or wastewater. In addition, he is also Associate Director of the Center for Biocatalysis and Bioprocessing at the University of Iowa. Among his honors, he is a Diplomate of the American Academy of Environmental Engineers and received a Career Award from the National Science Foundation and Outstanding Achievement Award in Environmental Engineering from the University of Michigan. Alvarez received a B.S. in Civil Engineering from McGill University in Montréal, a certificate in Hazardous Waste Management from the University of California, Riverside, and both an M.S. and Ph.D. in Environmental Engineering from the University of Michigan, Ann Arbor.

David Andress
President
David Andress & Associates, Inc.

David Andress has more than 25 years of professional experience in energy systems, with a focus on analytic and policy initiatives. He has been President of David Andress & Associates, Inc. since 1987, working on numerous projects that support the U.S. Department of Energy. His expertise is in mathematical sciences, operations research, statistics, forecasting, economics, systems analysis, and computer applications, and he has developed a number of full-featured models for forecasting energy supply and demand and for simulating emerging energy systems and technologies. In addition, he has been involved in the energy area, with an emphasis on nuclear power and renewable fuels, since 1978, examining factors relating to the demand for biomass ethanol, including fuel characteristics, environmental impacts, infrastructure issues and policy options. Andress received a B.S. in Mathematics from Rensselaer Polytechnic Institute and an M.A. in Mathematics from the University of Maryland.

William P. L. Carter, Ph.D.
Research Chemist, Statewide Air Pollution Research Center and College of Engineering Center for Environmental Research and Technology
University of California, Riverside

Bill Carter holds a joint appointment at the Air Pollution Research Center and College of Engineering Center for Environmental Research and Technology at the University of California, Riverside, where he has conducted research on photochemical pollution since 1973. His research focuses on the gas-phase atmospheric reactions of volatile organic compounds and the assessment of ozone and other impacts of volatile organic compounds in the atmosphere. Current projects include developing a new environmental chamber facility for a more comprehensive evaluation of mechanisms for gas-phase and particle formation reactions, and developing improved experimental methods for volatile organic compound reactivity assessment that can be applied to compounds where environmental chamber methods are not suitable. Carter received a B.A. in Chemistry from the University of California, Riverside, and a Ph.D. in Physical Chemistry from the University of Iowa.

Mary Ann Curran
Life Cycle Assessment Research Program Manager, National Risk Management Research Laboratory
U.S. Environmental Protection Agency

An expert in life cycle assessment, Mary Ann Curran provides technical support to several U.S. Environmental Protection Agency offices in developing policy and regulations, including guidelines for the federal procurement of environmentally preferable products. Currently, she directs the System Analysis Branch's Life Cycle Assessment research program, which includes the development of life cycle analysis methodology, the performance of life cycle case studies, life cycle workshops and conferences, and the development of a life cycle data directory website. In addition, she a member of the International Standards Organization life cycle assessment subcommittee and the Canadian Standards Association life cycle design committee. She also serves on the editorial boards of the *International Journal of Life Cycle Assessment* and *Environmental Progress*, as well as the Executive Committee for the American Center for Life Cycle Assessment. Curran received a B.S. in Chemical Engineering from the University of Cincinnati and an M.S. in Environmental Management and Policy from Lund University in Sweden.

James M. Davidson, P.G.
President
Alpine Environmental, Inc.

Jim Davidson has extensive experience investigating and remediating petroleum releases and has been involved with more than 400 contamination projects across the United States and internationally since 1984. He is a nationally recognized expert on the subsurface occurrence, movement, and remediation of MTBE and has authored/co-authored 15 publications on a variety of MTBE/fuel oxygenate issues, including *Treatment Technologies for the Removal of MTBE from Drinking Water* (California MTBE Research Partnership, 1999). He has also taught MTBE training sessions on more than 50 occasions for a variety of regulatory agencies and professional organizations. In addition, Davidson is a member of an elite U.S. Navy science panel addressing complex MTBE problems. He received a B.S. degree in Geology from the University of Massachusetts and a M.S. in Hydrogeology from Colorado State University.

J. Michael Davis, Ph.D.
Senior Scientist, National Center for Environmental Assessment
Office of Research and Development
United States Environmental Protection Agency

J. Michael Davis has worked with the U.S. Environmental Protection Agency for more than 20 years, primarily in assessing the health risks associated with lead, manganese, MTBE, alcohols, and other fuels and fuel additives. Over the past several years, he had helped formulate and coordinate research programs on these and other issues, including chairing U.S. Environmental Protection Agency workshops on oxygenate information and research needs and participating in a U.S. Environmental Protection Agency Blue Ribbon Panel on oxygenates in gasoline. Davis received a B.A. in Psychology from Concord College in West Virginia and a Ph.D. in Experimental Psychology from Duke University. Postdoctoral work included fellowships at the University of Oxford in England for Zoology and from the University of North Carolina at Chapel Hill in Neurotoxicology.

Rula A. Deeb, Ph.D.
Senior Environmental Engineer/Bioremediation Specialist
Malcolm Pirnie, Inc.

Rula A. Deeb is a Senior Project Engineer and Bioremediation Specialist for Malcolm Pirnie, Inc. Her expertise includes water and wastewater treatment and hazardous waste remediation, with an emphasis on bioremediation. Over the last several years, she has developed and implemented research programs at the University of California, Berkeley, on the *in situ* bioremediation of sites impacted with contaminant mixtures, including gasoline aromatics and fuel oxygenates. Since joining Malcolm Pirnie 2 years ago, Deeb has managed soil and groundwater remediation projects in addition to technology evaluations. Most of her efforts have focused on evaluating the environmental occurrence, fate, and transport of gasoline oxygenates in subsurface environments and the remediation of sites contaminated with oxygenate-blended fuels. Deeb received B.A. degrees in Mathematics, Chemistry, and Computer Science from Warren Wilson College in North Carolina, and both an M.S. and Ph.D. in Civil/Environmental Engineering from the University of California, Berkeley.

Mark A. Delucchi, Ph.D.
Research Scientist, Institute of Transportation Studies
University of California, Davis, California

Mark Delucchi has conducted research in the Institute of Transportation Studies at the University of California, Davis, since 1991. Recent studies have focused on the life cycle of battery-powered electric vehicles; life cycle emissions analysis of urban air pollution and greenhouse gasses from fuels; health and visibility coasts of air pollution; and crop damage costs from motor-vehicle air pollution. He also works as a private consultant for organizations such as the U.S. Department of Energy, Argonne National Laboratory, Oak Ridge National Laboratory, U.S. Federal Highway Administration, U.S. Congress Office of Technology Assessment, U.S. Energy Information Administration, World Bank, and others. Delucchi received both a B.A. and M.S. in Architecture from the University of California, Berkeley, and a Ph. D. in Ecology from the University of California, Davis.

Brendan P. Dooher, Ph.D.
Engineer
Lawrence Livermore National Laboratory

Brendan Dooher is a Lawrence Livermore National Laboratory engineer currently on change of station in Washington, DC, where he is a Fellow at the National Academy of Engineering. While there, he has been working on energy systems, carbon sequestration, and the roadmap for a transition to a hydrogen economy. Dooher has worked closely with the California State Water Resources Control Board to develop their GeoTracker internet-based database and geographic information system, which is currently collecting monitoring-well positions, chemical analysis, and groundwater levels from over 15,000 leaking underground fuel tank sites throughout the state. Additionally, he conceived and is helping the California State Water Resources Control Board to implement an assessment of drinking-water well vulnerability based on age dating of the well water and low level volatile organic chemical sampling. Dooher received a B.S., M.S., and Ph.D. in Mechanical Engineering from the University of California, Los Angeles.

Donna L. Drogos, P.E.
Senior Civil Engineer
Alameda County Health Department

Donna Drogos has over 13 years of civil and environmental engineering experience and has been a regulator, responsible party, and consultant for fuel leak sites. Her current work focuses on fuel oxygenate contamination in groundwater. Drogos recently joined the Alameda County Health Department in February 2002 as Senior Civil Engineer. Prior to that, she was Senior Civil Engineer at GeoSyntec Consultants and Civil Engineer for the Leaking Underground Storage Tank Local Oversight Program at the Santa Clara Valley Water District, where she developed the district's model letter for performing MTBE investigations and analyses for fuel oxygenates. She was also founder and former Chair for the Northern California MTBE & Fuel Oxygenates Committee. Drogos received a B.S. degree in Civil Engineering from the University of California, Berkeley, and is a Registered Civil Engineer in the State of California.

Stanley Durkee
Senior Environmental Analyst, Office of Research and Development
U.S. Environmental Protection Agency

Stanley Durkee is a Senior Environmental Analyst in the U.S. Environmental Protection Agency's Office of Research and Development, with broad experience in addressing various environmental issues, including 20-years experience working on fuels-related policy and scientific assessment issues. In his current position, he serves as link between the U.S. Environmental Protection Agency's policy-makers/regulators and the Office of Research and Development's scientists/science managers. He also coordinates teams of scientists in the Office of Research and Development to evaluate fuel-related health and exposure studies and to prepare assessments of exposures and risks associated with motor fuels and fuel additives, including oxygenates. Durkee received a B.A. in History from Amherst College and an M.P.A. in Public Administration from George Washington University.

Glenn Giacobbe
Business Development Manager for Oxygenated Fuels
Lyondell Chemical Company

Glenn Giacobbe is the Business Development Manager for Oxygenated Fuels with Lyondell Chemical Company in Houston, Texas. His primary responsibility is to add value to the C4 chain of products within Lyondell's portfolio, of which MTBE is a critical component. Glenn began his career with Atlantic Richfield Company in 1981 as a Refinery Process Engineer and has held various engineering, commercial, and management positions in the refining and chemical industries. He spent 6 years with BP in the early 1990s prior to joining ARCO Chemical Company in 1996 (ARCO Chemical Company became part of Lyondell Chemical Company in 1998). Giacobbe received a B.S. in Chemical Engineering from Carnegie Mellon University and an MBA in Finance from Drexel University.

Rick Handley
Program Director, Northeast Regional Biomass Program
Coalition of Northeastern Governors' Policy Research Center

Rick Handley has over 25-years experience in energy conservation and renewable energy. Since 1993, he has been Biomass Program Director for the Coalition of Northeastern Governors' Policy Research Center in Washington, DC, where he has presided over a transition of the Northeast program from an exclusive focus on biomass power to a split of emphasis on biomass power and liquid transportation fuels. Under his guidance, the region has been active in attracting the development of ethanol, biodiesel, and other biomass-derived liquid transportation fuels in the region. In addition, he serves as a board member of the Biomass Energy Resource Center, Inc., a public benefit corporation established to assist in the development of bioenergy projects across the United States and around the world. Handley received a B.A. in Behavioral Sciences from the State University of New York College of Technology.

Cal Hodge
President
A 2nd Opinion, Inc.

Cal Hodge has 34 years experience in refining and petrochemicals economics, feedstock selection, strategic planning, fuels formulations, governmental affairs, litigation, product distribution, industry analysis, and regulatory compliance. At present, he is President of A 2nd Opinion, Inc., a consulting firm that he founded in 1998 to advise refining, petrochemical, automotive, and governmental clients on regulatory, clean fuels, and economic issues. His practical experience with hydrocarbon-based fuels includes source, gathering and transportation to conversion centers, conversion to usable products, transportation of usable products to end users and the waste products, as well as the pollution associated with their production, transportation, conversion and use. Hodge received a B.S. in Chemical Engineering from the University of Kansas.

Michael E. Honeycutt, Ph.D.
Senior Toxicologist
Texas Natural Resource Conservation Commission

Mike Honeycutt is a Senior Toxicologist and Team Leader in the Toxicology & Risk Assessment Section of the Texas Natural Resource Conservation Commission (TNRCC), where he has worked for over 5 years. He serves as the TNRCC representative on the Toxicology Subcommittee of the Interagency Perchlorate Steering Committee and as Lead Toxicologist for the TNRCC Perchlorate Working Group. In addition, he is Lead Toxicologist for the TNRCC MTBE Working Group. Honeycutt's current responsibilities include reviewing and conducting human health risk assessments for hazardous waste sites and for hazardous waste combustion facilities; performing health effects reviews on air permit applications and on the results of ambient air monitoring projects; and serving as a technical resource for TNRCC staff on issues concerning sediment and water quality, drinking water contamination, and soil contamination. Honeycutt received a B.S. and Ph.D. in Toxicology from Northeast Louisiana University.

John J. Kneiss
Vice President, Regulatory and Technical Affairs
Oxygenated Fuels Association, Inc.

John Kneiss has over 25 years of professional experience, including over 14 years in the field of fuel oxygenates research and performance evaluations. As Vice President of Regulatory and Technical Affairs for the Oxygenated Fuels Association, Inc., he directs and manages scientific, technical, and regulatory activities related to oxygenates; develops and coordinates strategic initiatives that support and advance the benefits of oxygenates; and directs projects addressing scientific issues on oxygenates and cleaner-burning gasoline, including water resources protection and air quality. He has become a leading spokesperson on behalf of the Oxygenated Fuels Association and oxygenates industry regarding health sciences and technical information for oxygenates, and he has testified at numerous hearings at federal and state levels. Kneiss received a B.S. in Biology and Chemistry from Wilkes University and an M.S. in Environmental Sciences and Engineering from Virginia Polytechnic Institute and State University.

Jeff Kuhn
Petroleum Release Section Manager
Remediation Division in the Department of Environmental Quality
State of Montana

During his career, Jeff Kuhn has actively managed hundreds of petroleum release sites and worked with many state and federal agencies, local officials, industry, and the public in addressing petroleum-contaminated sites. Currently, he is the Petroleum Release Section Manager for the Remediation Division in the Department of Environmental Quality for the State of Montana as well as Chair of the Association of States and Territorial Solid Waste Management Officials' MTBE and Fuel Oxygenates Workgroup, which is involved in the remediation of impacted drinking-water supplies. He has also collaborated with the Montana State University Center for Biofilm Research on petroleum-related research projects since 1994, and has initiated several projects with the Center for Biofilm Research, including a five-site study for natural attenuation potential, among others. Kuhn received a B.S. in Geology from Juniata College and a M.S. in Geology from the University of Montana.

David W. Layton, Ph.D.
Division Leader, Health and Ecological Assessment Division
Lawrence Livermore National Laboratory

David Layton has over 30 years experience as an environmental scientist. At present, he is Division Leader of the Health and Ecological Assessment Division at Lawrence Livermore National Laboratory, where he has worked since 1983. Research interests include exposure assessment, risk analysis, environmental control technologies, water resources, and environmental impacts of energy technologies. In addition, he is the Elected Director of the Alameda County (California) Flood Control and Water Conservation District (Zone 7) and is a member of the Editorial & Advisory Board of Soil & Sediment Contamination for the Association for the Environmental Health of Soils. Layton received a B.A. in Earth Sciences from Bridgewater State College in Massachusetts and a Ph.D. from the University of Arizona.

Lester B. Lave, Ph.D.
Higgins Professor of Economics
Carnegie Mellon University

Lester Lave is University Professor and Higgins Professor of Economics at Carnegie Mellon University, with appointments in the Business School, Engineering School, and Public Policy School. His research interests focus on health, safety, energy, and environmental issues. Lave is also Co-director of the Carnegie Mellon Electricity Industry Center, which focuses on long-term, strategic issues within the electricity industry, and is Director of the Green Design Initiative, an institute that examines how to improve product and process design to improve environmental quality and sustainability. In addition, he is the author of over 500 scientific articles and books and has provided services for the National Academy of Sciences, U.S. Environmental Protection Agency, Federal Trade Commission, White House, and U.S. Departments of Defense, Energy, Transportation, Health, and Human Welfare, among others. Lave received a B.A. in Economics from Reed College and a Ph.D. in Economics from Harvard University.

Heather L. MacLean, Ph.D.
Assistant Professor, Department of Civil Engineering
University of Toronto

Heather MacLean became Assistant Professor in the Department of Engineering at the University of Toronto in 2000, following her tenure as a Postdoctoral Fellow at Carnegie Mellon University. Her dissertation, completed in 1998, was on "Life Cycle Models of Conventional and Alternative-fueled Automobiles." Current research awards include, among others, an evaluation of economic and sustainability implications of a lignocellulosic ethanol industry for Ontario (with the Ontario Ministry of Agriculture); economic and sustainability of alternative fuels (with General Motors); and cost-effective energy recovery from anaerobically treated wastewater solids (with the Water Environment Research Foundation). MacLean received a B.S. in Civil Engineering from the Technical University in Nova Scotia, an MBA from Saint Mary's University in Nova Scotia, and both an M.S. in Engineering and Public Policy and a Ph.D. in Civil Engineering and Engineering and Public Policy from Carnegie Mellon University.

Jeffrey Moller
Partner
Blank Rome Comisky & McCauley LLP

Jeffrey Moller is a practicing attorney and partner in the Philadelphia office of Blank Rome Comisky & McCauley LLP. For the past 3 to 4 years, he has been highly involved in litigation and public-policy issues pertaining to MTBE and its alternatives. During the 17 years that he has practiced law, Moller has advised transportation companies, oil refiners, and petrochemical manufacturers with regard to these and other related issues. In addition, Moller graduated from the U.S. Coast Guard Academy in 1976. His commissioned service in the Coast Guard included a concentration on marine oil spill prevention/response and the safe marine transportation of oil and petrochemicals. Moller received a B.S. in Government from the U.S. Coast Guard Academy and a J.D. at Temple University Law School.

William J. Piel
Director
TEIR Associates, Inc

Bill Piel formed his own consulting firm in 1999 after working for ARCO and ARCO Chemical Companies for 23 years in transportation fuel quality-related positions. His firm, TEIR Associates, Inc., provides analysis in developing environmentally sound and high performance transportation motor fuels for automotive vehicles and covers a range of fuel-related issues, including environmental, regulatory, economic and fuel quality. Some of his most recent work has been managing a screening program for preferred clean diesel fuel properties for future light duty vehicles under a CRC program, and developing options and economics for potential future H2 infrastructures for supplying fuel cell vehicles under a U.S. Department of Energy program. Piel received a B.S. in Chemical Engineering (Minor in Economics) from Lehigh University and an MBA in Finance from Widener University.

Susan E. Powers, Ph.D.
Assistant Professor, Department of Civil and Environmental Engineering
Clarkson University

Susan Powers is both Associate Professor in the Department of Civil and Environmental Engineering and Interim Director of the Center for Environmental Management, where she has taught and conducted research since 1992. Her research interest is on understanding the physical and chemical phenomena associated with multiphase flow and contaminant transport in subsurface systems, with specific emphasis on the fate, transport, and remediation of nonaqueous phase liquids in complex systems. Current research projects include life cycle management issues for gasoline and other transportation fuels as well as the complexities associated with aquifer heterogeneities and non-ideal chemical mixtures, such as coal tars and oxygenated gasoline. Powers received both a B.S. in Chemical Engineering and M.S. in Civil and Environmental Engineering from Clarkson University and a Ph.D. in Environmental Engineering from the University of Michigan.

Robert E. Reynolds
President
Downstream Alternatives, Inc.

Bob Reynolds' career in transportation fuels spans 25 years and includes a variety of diverse positions that encompass nearly every aspect of the downstream portion of the fuels industry. At present, he is President of Downstream Alternatives, Inc., which provides consultation services to a variety of industry and government clients with fuel-related interests. His activities focus on those areas of the petroleum industry that occur downstream of the refinery, with particular interest in oxygenated fuels and logistics. He has been engaged in numerous projects involving fuel blending, product quality assurance, transportation and logistics, and terminal operations, as well as terminal and retail unit conversions to oxygenated fuels. In addition, Reynolds has authored numerous papers and studies on fuel-related topics, including *The Current Fuel Ethanol Industry Transportation, Marketing, Distribution, and Technical Considerations* (2001) and *Infrastructure Requirements for an Expanded Fuel Ethanol Industry* (2002).

David W. Rice, Jr.
Environmental Scientist, Environmental Restoration Division
Lawrence Livermore National Laboratory

David Rice has worked at the Lawrence Livermore National Laboratory in California since 1976, focusing his research on the environmental impacts of transportation fuels, fate and transport of subsurface contaminants, environmental remediation, and toxicology of the early life and reproduction of fish. For the past four years, he has been the Group Leader of the Environmental Chemistry and Biology Group for the Environmental Restoration Division of the Lawrence Livermore National Laboratory. In addition, since 1999, he has been the Project Director for evaluating the potential surface and groundwater impacts that may result from the use of ethanol as a replacement for MTBE in gasoline. Rice received a B.A. in Life/Physical Sciences at California State University San Jose and an M.A. in Biology from California State University Hayward.

Andrew G. Salmon, Ph.D.
Senior Toxicologist and Chief
Air Toxicology and Risk Assessment Unit
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Andy Salmon is Senior Toxicologist and Chief in the Air Toxicology and Risk Assessment Unit of the Office of Environmental Health Hazard Assessment for the California Environmental Protection Agency, where he has worked since 1988. Among his responsibilities, he develops risk assessments for a number of air pollutants that are mobile-source related and, therefore, directly influenced by current or proposed fuel composition. He is also evaluating public health standards for acrolein, diesels exhaust particulate, dioxins, and polycyclic organic matter (all products of gasoline- and diesel-fueled vehicles) as air toxics of particular concern because of their specific impacts on children's health. In addition, he was editor of the health effects section of the report, *Health and Environmental Assessment for the Use of Ethanol as a Fuel Oxygenate* (1999), for the California Environmental Policy Council. Salmon received a B.A., M.A., and Ph.D. in Biochemistry from Oxford University.

John Sheehan
Senior Research Engineer
National Renewable Energy Laboratory

John Sheehan is a chemical engineer with over 20 years of experience in biotechnology and biochemical engineering. For the past 10 years, he has worked on or managed projects related to the development of renewable fuels at the National Renewable Energy Laboratory. This includes managing the Department of Energy's Biodiesel Program, as well as strategic planning and analysis for the Biofuels Program (bioethanol focus). As a strategic analyst for biofuels, Sheehan has conducted two major life cycle studies on renewable fuels: biodiesel made from soybean oil and ethanol made from agricultural residues. Prior experience includes working for W.R. Grace's corporate research center, where he specialized in fermentation and downstream recovery processes for biologically derived specialty chemicals, and for Merck Pharmaceutical, where he supported the commercial production of a recombinant hepatitis B vaccine. Sheehan received a B.S. in Biochemical Engineering from the University of Pennsylvania and an M.S. in Chemical Engineering from Lehigh University.

John Shipinski, Ph.D.
Senior Principal Engineer
Toyota Technical Center USA, Inc.

John Shipinski currently represents Toyota in a broad spectrum of industry activities intended to provide the fuels and lubricants needed to meet emissions regulations. He is a member of the Board of Directors of the Coordinating Research Council, which conducts research into the effects of fuels on performance and emissions from engines, as well as ambient air quality effects. He also represents Toyota in other fuels-related activities, including the World Wide Fuel Charter, the DOE APBF DEC Project, the Alliance of Automobile Manufacturers Fuels Work Group, ASTM International, and Society of Automotive Engineers, just to name a few. In addition, he is Chairman of the Board of the Test Monitoring Center for ASTM, operated by Carnegie-Mellon Institute with a self-sustaining budget of about two million dollars. Shipinski received a B.S, M.S., and Ph.D. in Mechanical Engineering from the University of Wisconsin.

Timothy J. Skone, P.E.
Environmental Engineer
Science Applications International Corporation

Tim Skone is a Professional Engineer in Environmental Engineering whose primary areas of expertise include evaluating products, processes, and activities through life cycle assessment based tools; developing methodologies and database tools to improve environmental decision making; and conducting pollution prevention opportunity assessments to identify and evaluate pollution prevention technologies and practices. His specific expertise is in developing state-of-the-art methodologies to evaluate human health and ecological impacts using the principles of life cycle assessment to compare environmentally preferable products and services. Skone is active in national and international organizations involved in advancing the science of life cycle assessment concepts while maintaining data integrity, quality, and transparency. He received a B.S. in Chemical Engineering from Pennsylvania State University.

Barbara M. (Bobbye) Smith, Ph.D.
Regional Science Liaison, Policy & Management Division
U.S. Environmental Protection Agency

Bobbye Smith is Regional Science Liaison to the Office of Research and Development for the U.S. Environmental Protection Agency, Region IX. Before joining the U.S. Environmental Protection Agency in 1994, she worked for the State of California San Francisco Bay Regional Water Quality Control Board as well as for an environmental consulting firm. Smith has participated on several environmental panels, including the State of California Comparative Risk Project, the Office of Research and Development's Science Policy Council Genomics Workgroup, and the Tribal Science Council. Her technical expertise includes ecologic risk assessment, effects of endocrine disrupting chemicals, and molecular biology. Smith received a B.S. in Zoology from the University of Michigan, an M.A. in Biology from California State University Hayward, and a Ph.D. in Botany from the University of California, Berkeley.

Michael Q. Wang, Ph.D.
Vehicle and Fuel Systems Analyst, Energy Systems Division
Argonne National Laboratory

Michael Wang is a Vehicle and Fuel Systems Analyst in the Energy Systems Division of the Center for Transportation Research at Argonne National Laboratory, where he has worked since 1991. His research interests include fuel-cycle analysis of the energy and emissions impacts of transportation fuels and advanced vehicle technologies; total energy-cycle analysis of electric vehicles and hybrid electric vehicles; and fuel infrastructure impacts resulting from the mass introduction of advanced vehicle technologies. He has developed a fuel-cycle model called Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) for evaluating energy and air emission impacts of vehicle/fuel systems. He has also produced several studies comparing vehicle/fuel systems on the full fuel-cycle basis. Wang received a B.S. in Agricultural Meteorology from Beijing Agricultural University in China, and both an M.S. and Ph.D. in Ecology from the University of California, Davis.

Walter J. Weber, Jr., Ph.D., P.E., D.E.E.
Gordon Maskew Fair and Earnest Boyce Distinguished University Professor
University of Michigan, Ann Arbor, Ann Arbor, MI

Walter Weber is an environmental scientist, engineer, and educator recognized for developing technologies for water treatment, water pollution control, reclamation, and reuse. He founded the Great Lakes and Mid-Atlantic Hazardous Substance Research Center and the National Center for Integrated Bioremediation Research and Development, both of which are supported by the U.S. Environmental Protection Agency, U.S. Department of Defense, U.S. Department of Energy, and several major industrial firms. He was named a Diplomate in the American Academy of Engineers in 1975 and elected to the National Academy of Engineering in 1985. Currently, he serves as Chair of the Research Advisory Committee for the California MTBE Research Partnership. He received a Sc.B. in Chemical Engineering from Brown University, M.S.E. in Environmental Engineering from Rutgers, and both an A.M. in Environmental Chemistry and Ph.D. in Water Resources Engineering from Harvard University.

James S. White
President/Principal
White Environmental Associates

Since 1995, Jim White has been President and Principal of White Environmental Associates, a company that helps businesses respond to environmental issues and challenges, including policy matters regarding petroleum storage facilities and clean burning fuels. Prior, he worked for ARCO Products Company, with responsibilities such as developing and implementing environmental compliance programs; establishing and managing ARCO's Methanol Fuel Program, as well as helping to develop the reformulated gasoline concept; and providing industry leadership in developing positions and responses to critical environmental issues. Other experience includes participating in the formation of the "Regulation of Underground Storage Tank" Task Force for the American Petroleum Institute; developing underground storage tank regulations with the U.S. Environmental Protection Agency; and consulting for Lyondell Chemical, a major manufacturer of MTBE, among others. White received a B.S. in Geology from the University of Delaware.

Pamela R. D. Williams, Sc.D.
Senior Scientist
Exponent

Pamela Williams has multidisciplinary training in risk assessment, cost-benefit analysis, and risk communication. She has evaluated human exposures and health risks to a variety of chemicals in air and drinking water, using statistical and probabilistic modeling and dose-reconstruction techniques. She also uses her expertise in risk-benefit and decision analysis to prioritize health and safety risks, identify unanticipated consequences of alternative actions, and establish cost-effective risk management goals. Her area of expertise includes analysis of the risks and benefits of fuel oxygenates like MTBE. She has also compared the detection frequencies, concentration levels, and relative health risks of six volatile organic compounds commonly found in drinking water to put the available MTBE data into perspective. Williams received a B.A. in Applied Social Research from San Diego State University and both an M.S. in Health and Social Behavior and Sc.D. in Environmental Science and Risk Management from Harvard University.

APPENDIX E

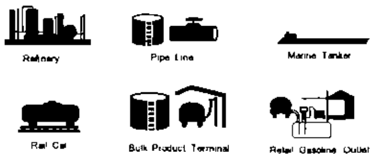
WORKING GROUPS' VISUAL PRESENTATIONS

WORKING GROUP 2

Fully Identify and Characterize Environmental Release Potential in the Manufacturing, Transport, Storage, and Handling Infrastructure

Fuel Lifecycle Impacts

Fully Identify and Characterize Environmental Release Potential in the Manufacturing, Transport, Storage and Handling Infrastructure.



Working Group Members

- Jeffrey Kuhn
- David Layton
- Jeffrey Moller
- James White

Issue Description

- Full identification and characterization of environmental release potential MTSHI
- Release potential includes accidental, routine, and secondary (e.g., mode of transportation) sources and causes.
- Characterize the uncertainty in direct & indirect releases
- Tracking analysis of the fuel through the MTSHI
- Comparison of the key differences in the MTSHI release potentials for various fuels

Rationale

Why is this issue important?

Evaluation of the environmental impacts of a fuel's life cycle depends on a thorough examination of releases to the environment.

Release estimates based on data or simulation are used as imputs to transport & fate, exposure, and risk models.

Imprecision in characterizing the release potentials of a given fuel lifeeycle will bias the assessment of impacts.

Approach

- Use available information to identify potential release points associated with a fuel's MTSHI.
- Where release data are limited, use simulation technologies to estimate releases or use release data from analogous fuel technologies.
- Identify key data gaps and characterize uncertainties in releases for accidental, routine and indirect sources.
- Conduct sensitivity analyses to identify parameters that have an important influence on environmental impacts as part of an integrated assessment of a fuel's lifecycle impacts.

Issue Resolution

Develop case studies demonstrating the process of identifying and characterizing releases from a fuel's lifecycle.

- USDOT OPS – FHSA
- Surface Transportation Board
- USEPA
- USCG
- API
- NACE

...Other stakeholders with interests in release identification and MTSHI system pollution prevention.

Questions Regarding California's Gasoline Issues?

http:www.CalGasoline.com/

Questions?

WORKING GROUP 3

Application of Human Health and Ecological Risk Assessment Framework to Evaluate the Life-Cycle Impacts of Fuel Options

Application of Human Health and Ecological Risk Assessment Framework to Evaluate the Life-Cycle Impacts of Fuel Options

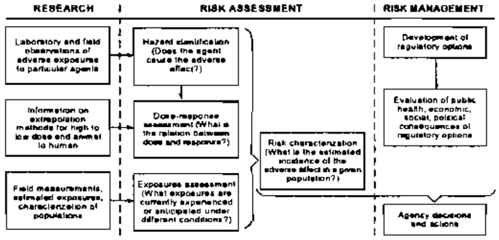
Mike Davis, USEPA
Michael Honeycutt, TNRCC
Andrew Salmon, Cal-EPA
Pamela Williams, Exponent

Multimedia Impacts

Description

- Comprehensive assessment of life cycle impacts is needed
- These "impacts" should be defined as health/ecosystem effects
- The risk assessment framework can be used to characterize these impacts

Risk Assessment Framework



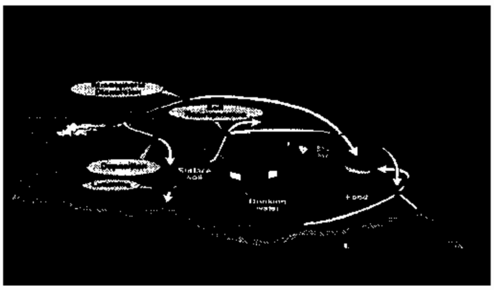
Hazard Identification

- The "hazard" must be identified prior to assessment
- Question is whether releases are likely to cause human health or ecological effects
- Data may be based on animals or humans

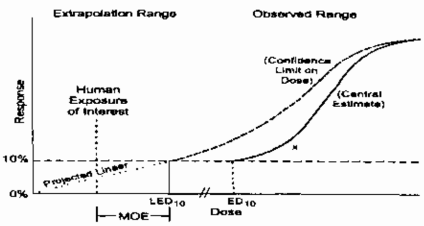
Exposure Assessment

- Multiple pathways and routes
- Cumulative exposures
- Frequency and duration
- Time-activity patterns
- Subpopulation groups (socioeconomic variables; susceptibilities)

Exposure Pathways



Dose Response Assessment



Toxicity Criteria

- Human Health
  - Reference concentration/dose
  - Minimal risk levels
  - Reference exposure levels
  - Maximum contaminant levels
  - Cancer slope/unit risk factors
  - Acute exposure guidance levels
- Ecological
  - Acute/chronic water quality criteria (fish)
  - Sediment quality criteria (benthics)
  - Toxicity reference values (critters)

Risk Characterization

- Synthesize exposure and effects data
- Provide quantitative and qualitative information
- Conduct uncertainty analyses and discuss data limitations


Risk Comparisons

- Evaluate relative health risks and benefits
- Identify possible tradeoffs
  - Different population groups
  - Different effects
  - Human health versus ecological impacts
  - Health/ecological versus economics impacts
- Ultimate decision-making may need to account for public preferences and values

Importance

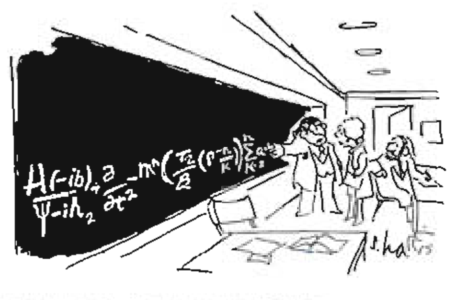
- Impacts of alternative fuels must be understood to inform decision-making
- Comparative evaluations of risks/benefits can result in public health/environmental improvements
- More comprehensive assessments can help identify data gaps and research needs

Address Issue

- Iterative process – should start early to allow time to develop missing data
- Assessments should address exposure conditions and effects of greatest likelihood and concern
- Focus should be **impact** driven (must move beyond inventory analysis)

Who Can Help?

- Assessment and evaluation of data
  - Government agencies
    - USEPA
    - Cal EPA
    - ATSDR
  - Other stakeholders
- Data generation
  - Health Effects Institute
  - Industry groups/trade associations
  - University research
  - Federal laboratories (NIEHS/USEPA)



"BUT THIS IS THE SIMPLIFIED VERSION FOR THE GENERAL PUBLIC."

WORKING GROUP 10

Complete Goal and Scope Definition Is Important for Meaningful LCA Results and Should be Incorporated with Other Decision-making Tools

Working Group #10

Tim Skone, SAIC
Michael Wang, ANL
Glenn Giacobbe, Lyondell Chemical Co.

Issue Title:

Complete Goal and Scope Definition is Important for Meaningful LCA Results and Should be Incorporated with other Decision-making Tools

Why is this Issue Important?

- LCA is not a stand-alone decision-making tool!
- LCA results must be combined with other key decision-making information
  - Benefit-Cost Analysis
  - Risk Assessment
  - Economic Impacts
  - Social Considerations
- Inconsistent foundations leads to miss-informed decisions and the inability to combine/compare study results.

How Do We Resolve this Issue?

- Increased Attention to the Importance of Defining the Goal & Scope
- Communication of the Strengths and Weaknesses of Life Cycle Tools is Critical Early in the Study
  - to Stakeholders
  - to *Decision-Makers*

Important Goal & Scope Topics

- Scope Definition
  - Content
  - Temporal
  - Geographic
- Modeling Approaches
  - Technological Improvements
  - Sound Methodology (e.g., ISO 14040)
  - Appropriate Data Quality to Meet the Goal
- System Boundaries
  - Life Cycle Stages
  - Multi-Media Releases
  - Direct and Indirect Processes

Important Goal & Scope Topics

- Selection of Impact Categories
  - Ozone Depletion
  - Global Warming
  - Ecotoxicity
  - Human Health Effects
  - Acidification
  - Eutrophication
  - Smog Formation
  - Resource Supply/Depletion
  - Land Use
  - Water Use
  - *Other Impacts of Concern or Relevance*

Strengths and Weaknesses of Life-Cycle Impact Considerations

Strengths

- Systematic evaluation of all relevant impacts.
- Identifies significant shifts between life-cycle stages & env. media.
- Identifies impacts to one or more area of concern.
- Identifies areas for system improvement.
- Identifies the "total" consequences of a decision.

Weaknesses

- Order-of-magnitude uncertainty in results
- Lack of impact models to account for all known releases.
- Time & resources to conduct a life cycle study are greater than other traditional decision-making tools.

Who Are the Organizations Best Able to Address this Problem?

Anyone Attempting to Develop a Comprehensive Evaluation of Life Cycle Environmental Impacts!

Published February 22, 2002

By

NATIONAL WATER RESEARCH INSTITUTE
10500 Ellis Avenue
P. O. Box 20865
Fountain Valley, CA 92728-0865

National Water Research Institute Report Number NWRI-02-01