An LCA on PVC Packaging
A New Look at Methodology and Use of LCAs

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AN LCA ON PVC PACKAGING - A NEW LOOK AT METHODOLOGY AND USE OF LCAs

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I would like to tell you about an LCA project we have recently completed that Chem Systems believes, along with the Vinyl Institute, represents a milestone of progress in the field.

Although some of Chem Systems' senior staff were among the original practitioners of energy-focused LCAs in the early 1970s, for NATO and other public and private sponsors, the company was not directly involved in the more recent spate of environmentally - oriented LCAs. However, we were pursuing the related issues through many other activities of our core and environmental practices. When the Vinyl Institute asked us to perform an LCA on certain vinyl packaging products and some alternatives, we were able to make a fundamental appraisal of the whole subject, since we did not have any vested interest in the status quo.

There have been for a long time some glaring flaws in LCAs, such as the tendency of presenters or users to attempt to add together the weights of emissions of vastly dissimilar materials, with or without "weighing factors", to derive glib, but meaningless "bottom lines" for comparisons. Also, seldom was the issue of data uncertainty broached. We proposed an approach that would address these and many other, sometimes divergent criticisms that have been leveled at LCAs recently.

Clearly, the public is disenchanted with LCAs because of the conflicting conclusions that have been published, and because of reversals of decisions by businesses based on them. It gives people the impression that someone is "cooking the books", so that it is likely there will eventually be much resistance to prescriptions based on these studies of which materials, products or systems are best for the environment. The public generally believes that science has precise answers to concerns and problems, but they also tend to believe that industry and its scientists are barely to be trusted with their health and safety. Doonesbury (Garry Trudeau) expressed the public confusion and skepticism very well in a recent cartoon on the subject.

LCAs need to be made more accessible to critical review and capable of being regularly updated to reflect the rapidly changing conditions of industry and society. They should be based as much as possible on publically available data, not private communications and estimates, and should analyze the uncertainties in their data. They should provide and discuss frames of reference for understanding the relative importance of factors inventoried. It is not enough to say, "this process emits a million pounds of ammonia per year!", without giving an understanding of what ammonia is, what it does to the environment, and what else emits it. It is widely agreed that dissimilar emissions should not be added together to achieve totals for comparisons, yet the practice continues. Pollutants are not fungible products like fuels, commodity materials, or electricity. LCAs should be performed, or at least guided, by individuals who are thoroughly expert and current in the industrial, utility, and other underlying processes used to obtain products. They should avoid facile assumptions in favor of their sponsors, or at least provide sensitivity analyses of the key assumptions. Their execution and analytical conclusions should reflect a healthy skepticism and acknowledgement of their limitations.

All of these "shalts" and "shalt nots" pointed Chem Systems to the development of an automatically-solving Lotus 1,2,3 (Version 3.1) spreadsheet model with open access to assumptions and key parameters to enable changes over time or for sensitivity studies. Figure 1 illustrates the overall architecture of the model. Figure 2 indicates the structural relationships and information flows among the model's process modules and information sources.

Our analysis also suggested that we reevaluate the traditional slate of inventoried pollutants to make them more responsive to the current state of knowledge and concerns. The 1990 report of the EPA's Science Advisory Board (SAB), a committee of remarkably broad scientific and community representation, set global air pollutants and toxics emissions as the highest priorities that can be qualitatively inventoried. This led us to select an ordered slate of "greenhouse" and ozone-depleting gases (including CO_2 and methane), the bulk of materials in the federal Toxics Release Inventory (TRI), and the Criteria Air Pollutants (SO_2, NO_x, CO, VOCs, and airborne particulates) as the priority species for our inventory. Figure 3 compares the 1988 estimated relative contributions of industrial processes and other sources of Criteria Pollutants in the U.S.

The TRI requires all significant manufacturing facilities to report annually on releases and transfers of 322 individual chemicals and groups. Figure 4 illustrates the scope of TRI releases considered in the study, as to chemical species in the TRI list, economic sectors covered, and relative magnitude of releases and transfers covered. Figure 5 indicates the complexity of the distribution of TRI chemicals among air, water, and land releases and transfers to treatment or disposal.

We made our models, and exercised them on cases of PVC detergent and oil bottles, thermoformed sheet blister pack and cartons, and plasticized film meat wrap, compared to alternatives in glass, HDPE, PET, PETG, SBS paperboard, and PE-coated kraft "butcher paper", respectively.

The model showed that PVC has modest advantages among the plastics products in total energy equivalents contained and released in manufacturing. Only glass bottles, even with the current substantial amount of recycling showed, a much greater energy requirements than PVC, while SBS paperboard showed a much lower energy requirement than PVC carton material. Related to these are similar distinctions in CO_2 and Criteria Pollutant emissions. Chem Systems cautions against making too much of these differences, because of the substantial uncertainties of total lifecycle models, in spite of the relatively accurate knowledge of energy requirements and process stoichiometry (material balances and yields).

Especially critical as "wild cards" are the energy and emissions for transportation, recycling, and disposal, which can be significant, but are poorly known. Figure 6 illustrates the wide diversity of transportation modes among various chemical commodity classifications. Compared to all the energy and by manufacturing industries in the U.S., including that imported for consumed electric power, freight transportation requires about another 22 percent. However, fuel and emissions can vary by several orders of magnitude among transportation modes on the basis of weights of various products transported.

As for toxics releases and transfers, some differences are apparent among products, but there are many qualifications. The most important is that the differences among facilities tend to be greater than among products. Figure 7 illustrates this point for key toxic emissions from a number of U.S. ethylene plants, which are diverse ir :heir capacities and feedstock mixes. The ranges of emissions of each pollutant cov · several orders of magnitude, and are greater than the difference among the PVC HDPE, and glass products compared. Ethylene plants are typical of the problem tha not all the facilities of a type can be included in a statistical analysis because many are v :hin complexes that report their emissions lumped together. A corollary is that the glit models that others have constructed of process emissions from various types of proc ;ses are useless at best, and misleading at worst. Further, the TRI reporting, the bes possible source of emissions data, does not extend to mining, transportation or to ommercial, military, public works, nuclear, or power utility facilities; it only covers manu cturing operations. Figure 8 illustrates the conceptual degradation of confidence towa ds the raw material supply and end use parts of the life cycle. Fortunately, the key naterial conversion processes are covered in the TRI.

Chem Systems cautions companies and agencies that it will r 'ely be feasible to "micromanage" the economy for the benefit of the environment by se ecting one product, material, or system over another using LCA environmental compa sons. The present state of knowledge simply does not justify such actions. We urge t at the TRI reporting be expanded to other sectors of the economy, which can be greate emitters of some of the species than are manufacturing operations. We also recomm nd that much more federal effort be spent on characterizing the energy budget of frei ht transportation, a significant energy and emission item with a high sensitivity to ; ;sumptions in LCA modeling.

We recommend that other practitioners and the EPA consider the n :thodology we have created and the cautions we have stated on uses of LCAs in their e orts to evolve a new universal standard.

Flaws of LCAs

- Sources and uses of data
- Poor quality, obscure models
- System definition - scope limitations
- Selection of effluent inventory species
- Presentation of results

Goals of Chem Systems/VI LCA

Scope - Complete systems analysis; full breadth of environmental concerns

Credibility - Involve peer reviewers, avoid facile assumptions

Flexibility - Lotus computer model

Accessibility - Discuss assumptions, disaggregate data

Objectivity - Avoid weighting factors or "bottom lines"

FIGURE 1

CSI LCA MODEL ARCHITECTURE

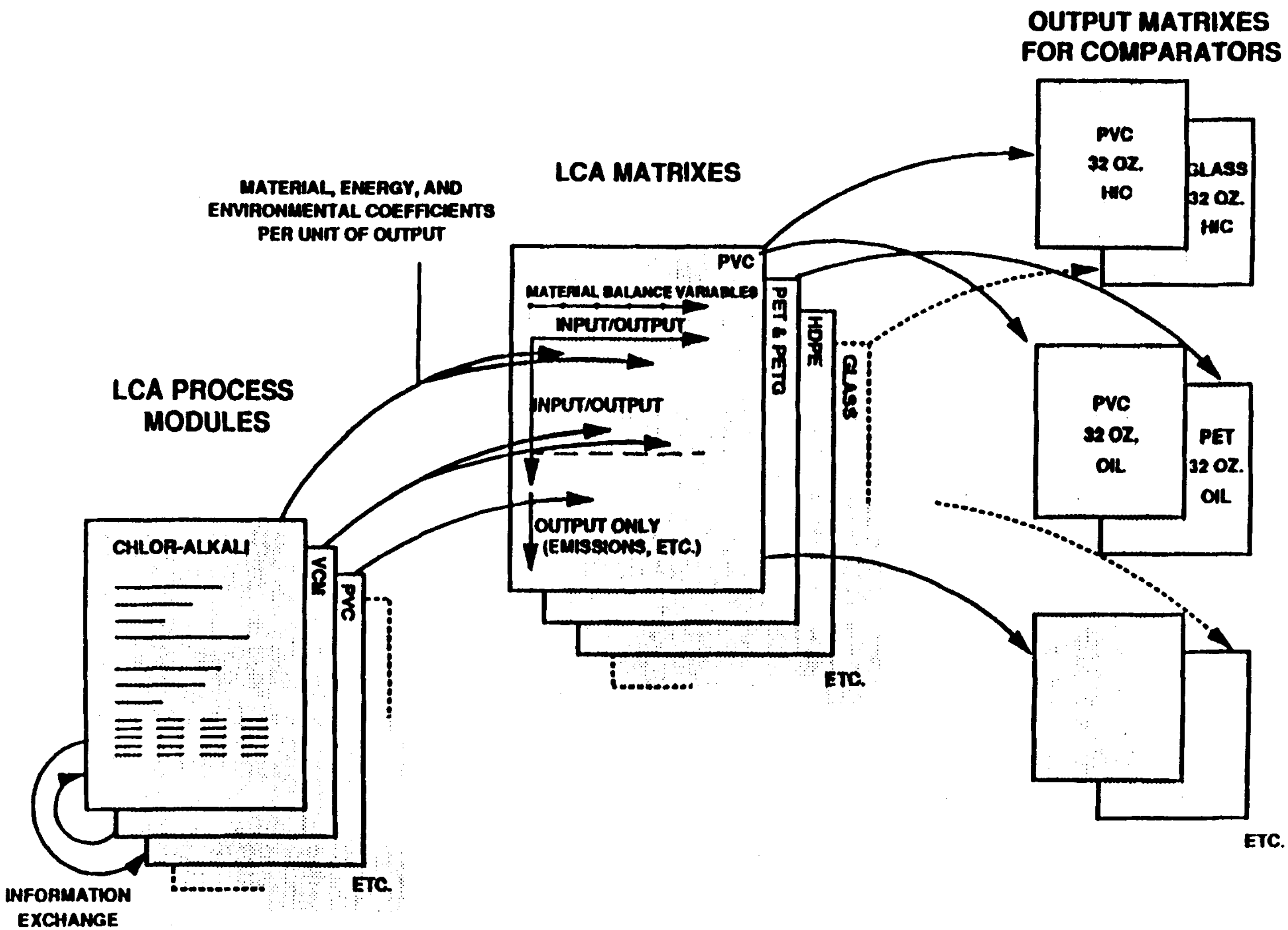

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FIGURE 2
MODEL COMPONENT RELATIONSHIPS

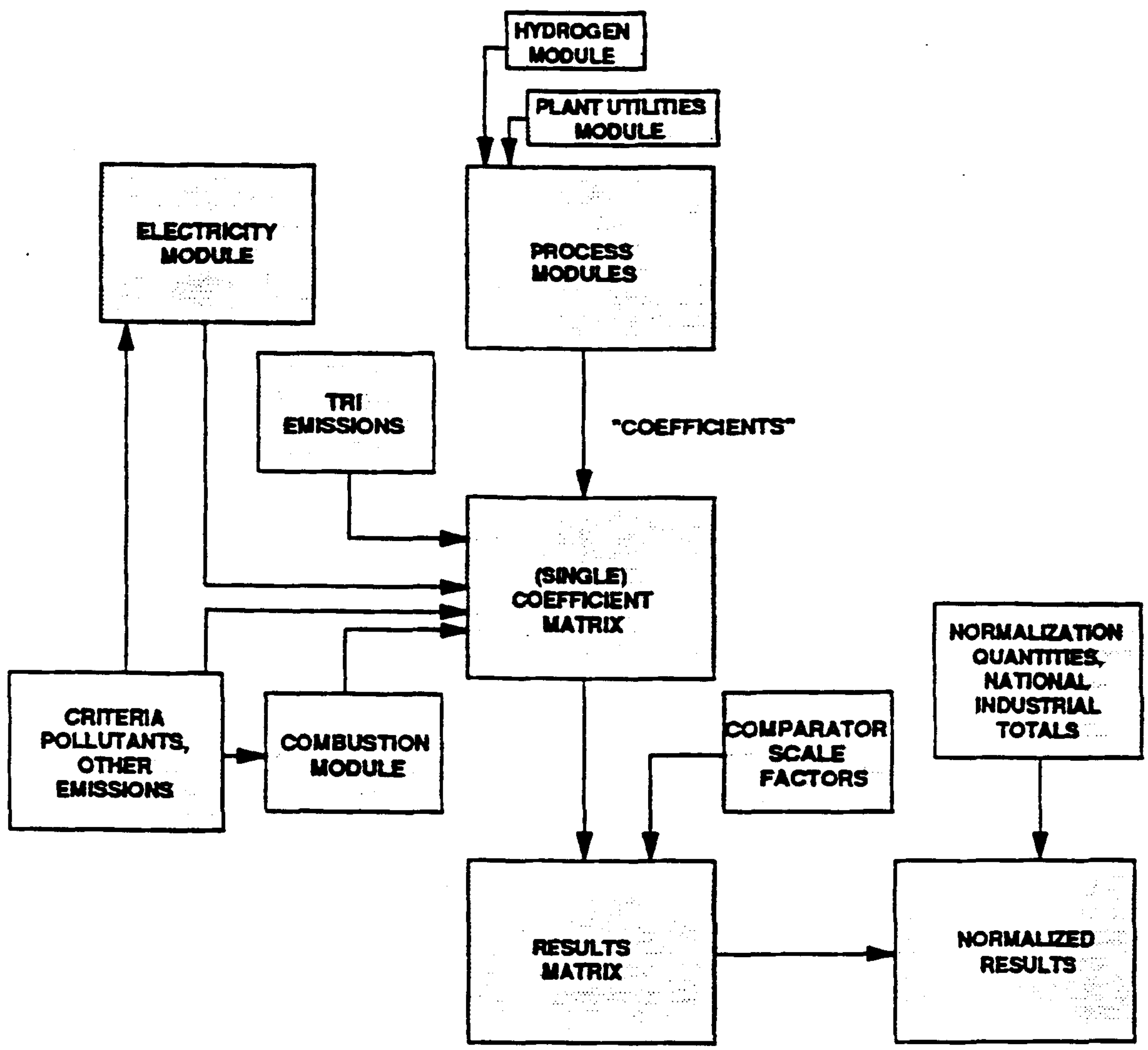

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FIGURE 3

EPA ESTIMATES OF 1988 EMISSIONS OF CRITERIA POLLUTANTS BY SECTOR

	Million Short Tons/Year				
	SO_x	NO_x	PM	CO	VOC
Total transportation	1.0	8.9	1.5	45.3	6.7
Stationary fuel combustion					
Electric utilities	15.0	7.8	0.5	0.3	0.0
Industrial	2.3	3.4	0.2	0.7	0.1
Commercial/institutional/residential	0.8	0.6	1.1	7.4	0.8
Industrial processes	3.7	0.7	2.9	5.2	9.4
Solid waste incineration	0.0	0.1	0.3	1.9	0.7
Forest fires	0.0	0.2	0.9	5.9	0.8
Other miscellaneous	0.0	0.0	0.1	0.7	1.9
Total of all sources	22.8	21.8	7.6	67.3	20.5

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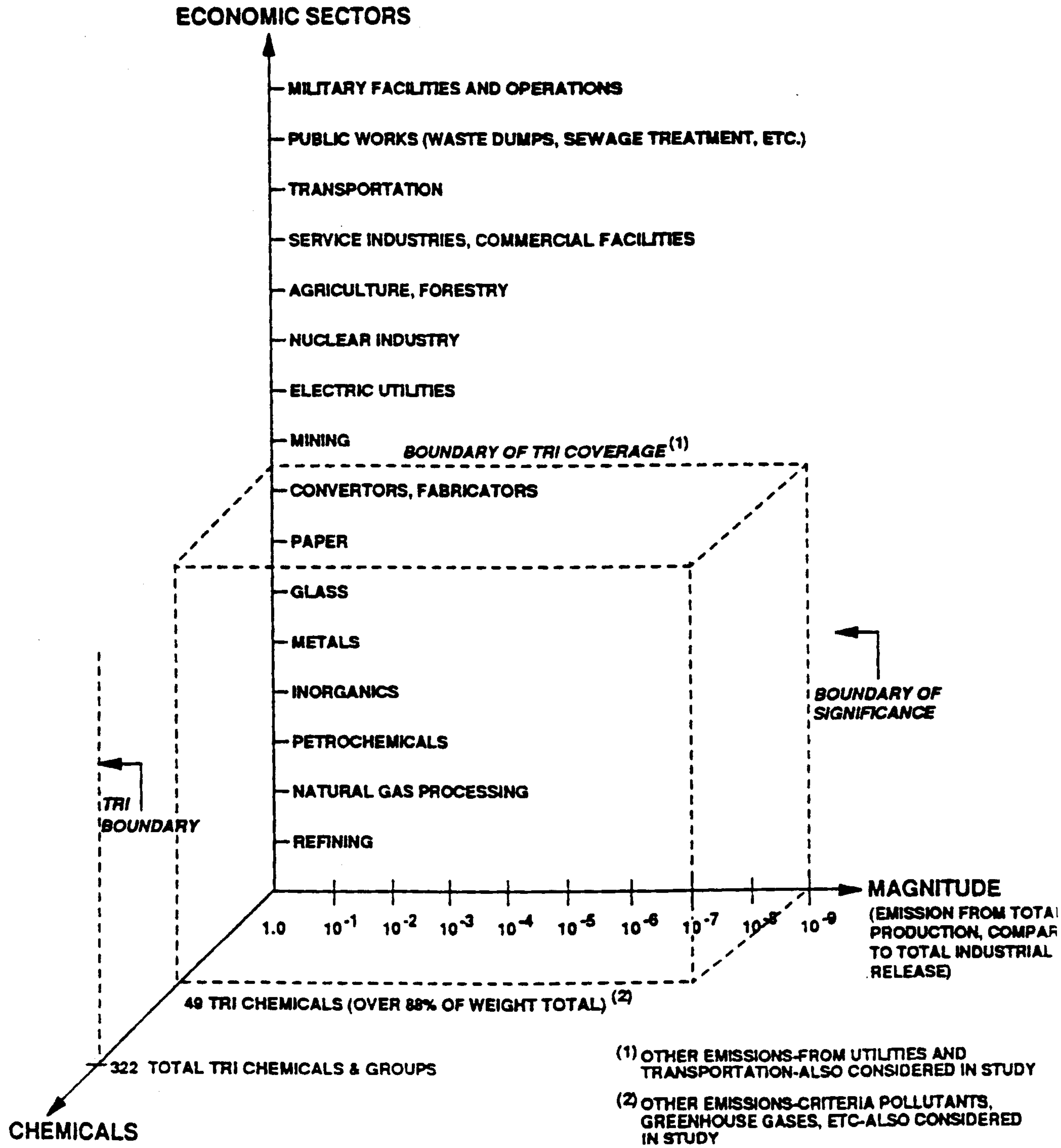
Emission data from the TRI

- Public data base - designed for accessibility
- Manufacturing industries are compelled to report (fines up to $25K/day)
- Industry reports annually
- Basis constantly reviewed, updated, challenged, debated
- Serves as the benchmark for U.S. industrial performance

Provides a consistent, credible, and relevant basis, but has some deficiencies

FIGURE 4

SCOPE OF TRI RELEASES CONSIDERED IN STUDY



(1) OTHER EMISSIONS-FROM UTILITIES AND TRANSPORTATION-ALSO CONSIDERED IN STUDY

(2) OTHER EMISSIONS-CRITERIA POLLUTANTS, GREENHOUSE GASES, ETC-ALSO CONSIDERED IN STUDY

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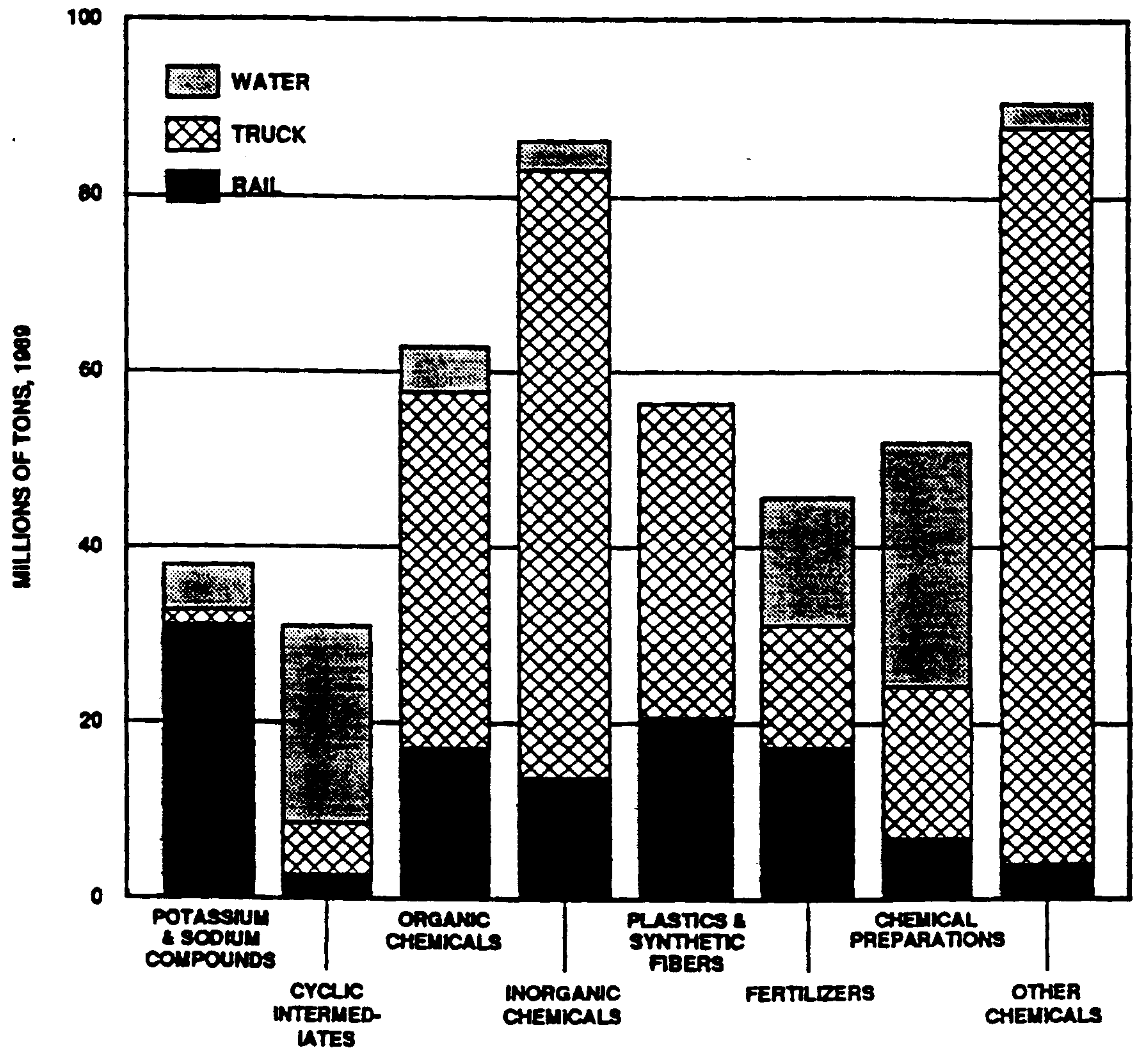
FIGURE 5

ENVIRONMENTAL DISTRIBUTION OF TRI RELEASES AND TRANSFERS

TRI Environmental Distribution	Percent
Release to air (fugitive and point source)	38.90
Release to surface waters	5.79
Release to land disposal	9.00
Public sewage treatment	9.14
Off-site treatment or disposal	17.70
Transfer to underground (deepwell) injection	19.47
Total	**100.00**

FIGURE 6

TRANSPORTATION VOLUMES AND MODES OF MAJOR CHEMICAL GROUPS



NOTE: FIGURES ARE FOR THE FIRST MOVEMENT FROM PRODUCTION TO CUSTOMER, WAREHOUSE, OR REDISTRIBUTION LOCATION; FOR SOME PRODUCTS THERE IS SIGNIFICANT SECONDARY SHIPMENT BY DISTRIBUTORS

SOURCE: C&EN, REEBIE ASSOCIATES, GREENWICH, CT.

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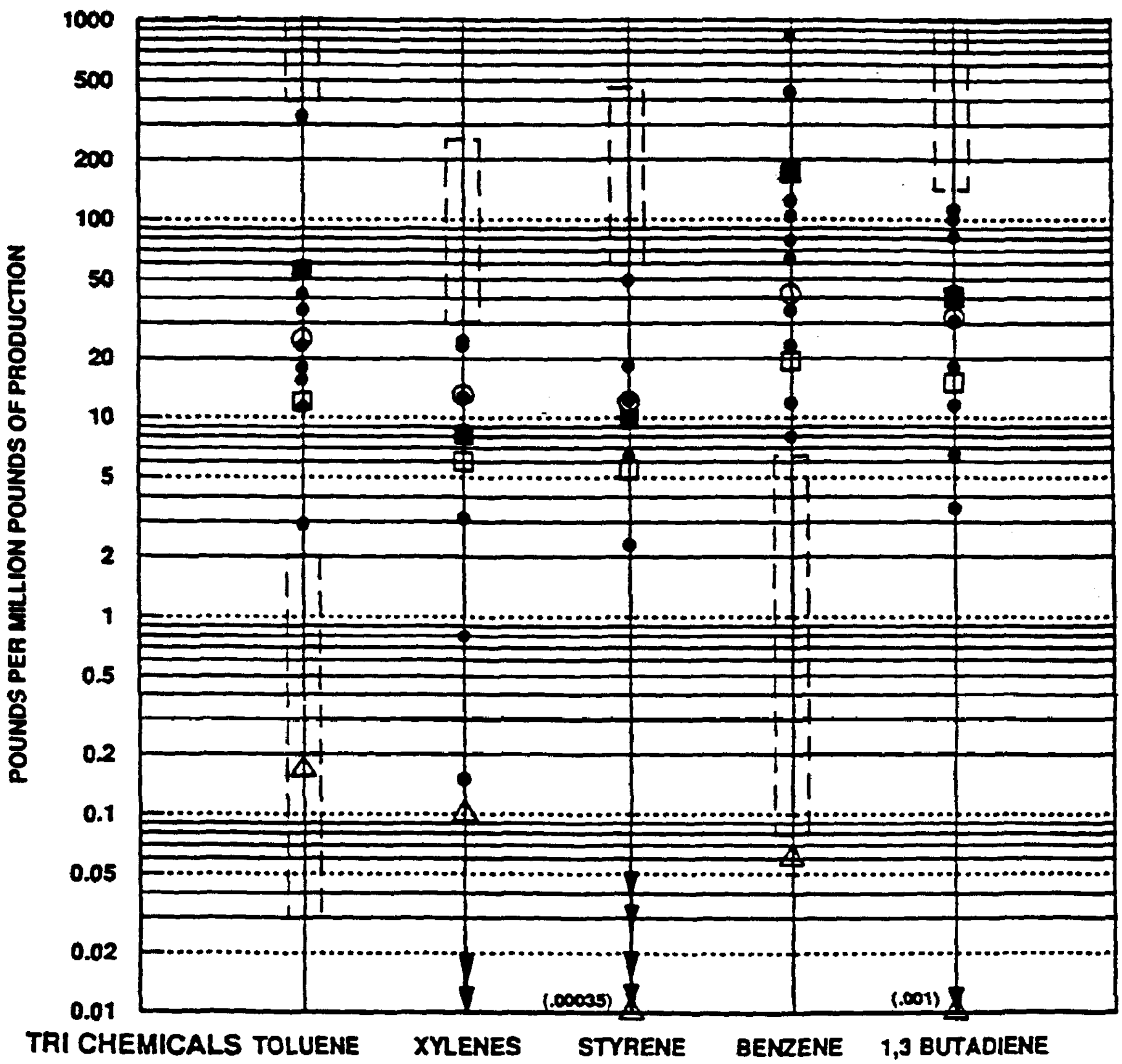
FIGURE 7

ANALYSIS OF SELECTED TRI EMISSIONS AMONG ETHYLENE PLANTS
(ON A SAMPLE OF 10 OF 35)



[ ] RANGE EXTENSIONS ASSUMING OTHER 25 ETHYLENE PLANTS HAVE EMISSIONS AMONG THEM 2 ORDERS OF MAGNITUDE LOWER AND ONE ORDER HIGHER THAN INDICATED RANGE FOR SAMPLE OF 10

ARROWS INDICATE CASES OF ZERO (OR BELOW MINIMUM) EMISSIONS REPORTED

LEGEND:
- ■ AVERAGE OF 10-ETHYLENE PLANT DATA SET
- □ PVC 32-OZ HIC BOTTLE TOTAL (EX. TRANSPORTATION)
- ○ HDPE 32-OZ HIC BOTTLE TOTAL (EX. TRANSPORTATION)
- △ GLASS 32-OZ HIC BOTTLE TOTAL (EX. TRANSPORTATION)

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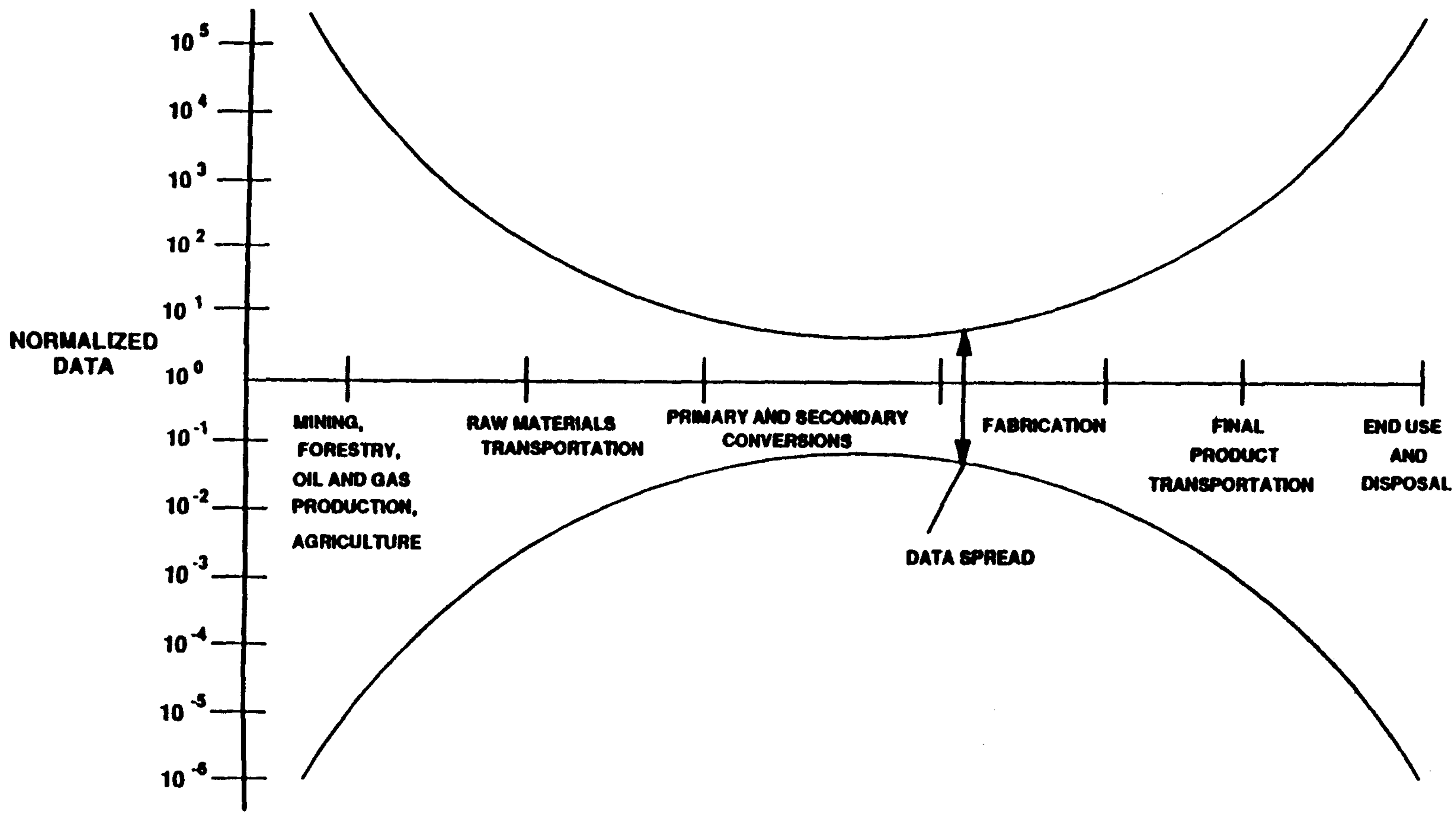
FIGURE 8

CONCEPTUAL CONFIDENCE LIMITS OF LCAs



Conclusions

- PVC generally has some energy advantages over most alternatives
- Conclusions on environmental issues are difficult, uncertainties overwhelm differences
- Don't "micro-manage" economy to achieve environmental improvement
- Use LCAs to help improve each product or system individually
- LCAs are better than anecdotal approaches
- Need much more work on LCA methodology and data base

Peer review feedback

- General approval of methodology - TRI use, computer program
- Past LCAs accurate and useful on energy analysis, but not on environment
- Differences between U.S. and European analyses - feedstocks, processes, transportation, data available