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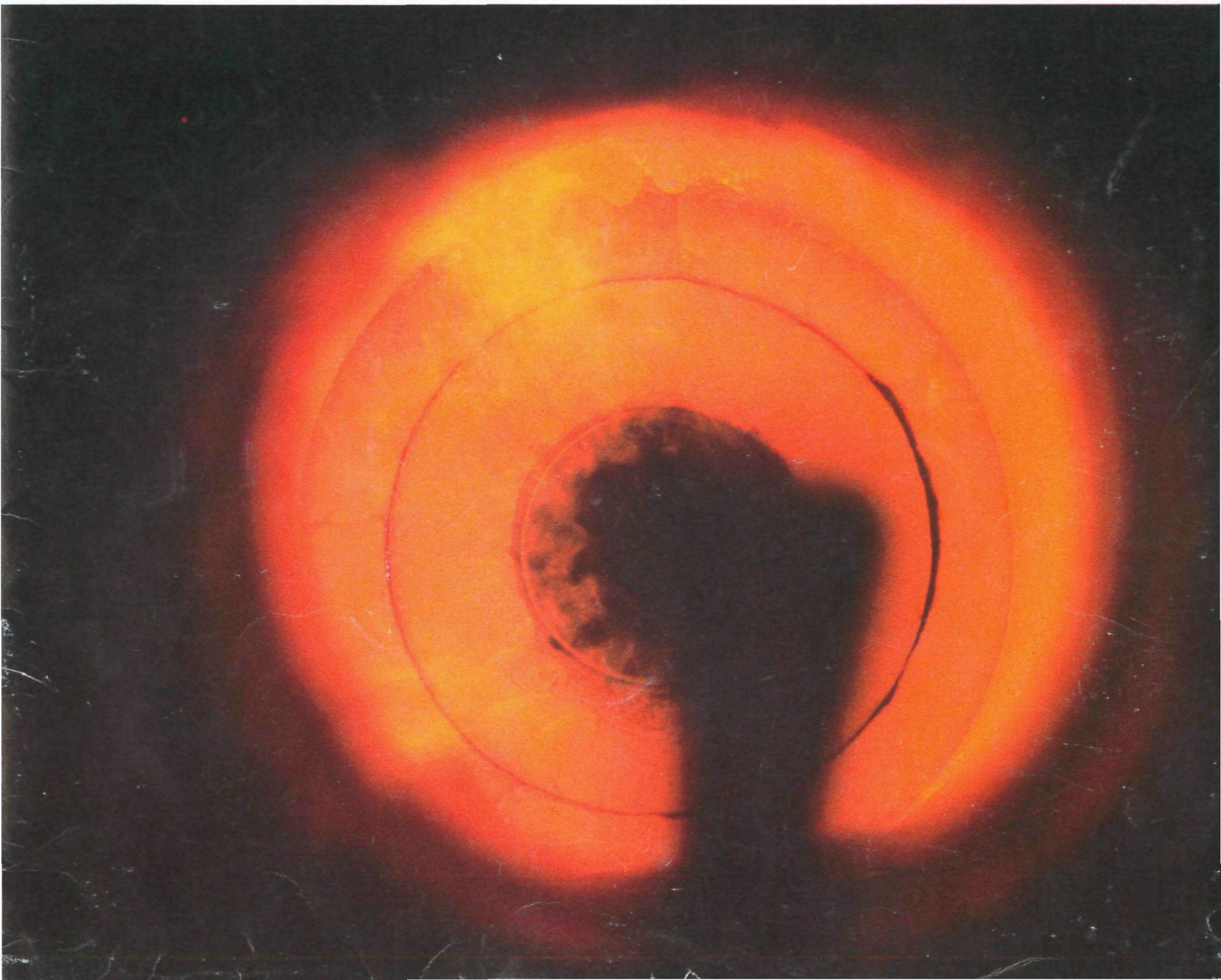
Research and Development

EPA

Executive Briefing

Conventional Combustion Environmental Assessment Program



Research and Development

Executive Briefing

Conventional Combustion Environmental Assessment Program

ACKNOWLEDGEMENTS

This publication is part of the EPA Information Transfer/Environmental Assessment executive briefing series. The purpose of the series is to inform government and private sector managers of significant results of EPA Office of Research and Development studies that may be helpful to them. This publication was prepared for EPA's Industrial Environmental Research Laboratory in Research Triangle Park, North Carolina, by Northrop Services, Inc.

NOTICE: Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency.

ON THE COVER: Tangentially fired boiler, modified for nitrogen oxides control.

CCEA

THE PURPOSE

To provide a comprehensive approach to protection of our health, and our air, land, and water resources from combustion-related pollution.

THE SCOPE

To identify, acquire, and analyze all information relevant to the environmental assessment of conventional combustion processes.

THE RESULTS

A defensible base for the development and promulgation of accurate control standards, a comprehensive information base for the accurate definition of control technology development needs, a reference list of CCEA-related research projects, and studies to fill identified gaps in available data and information.

THE BENEFITS

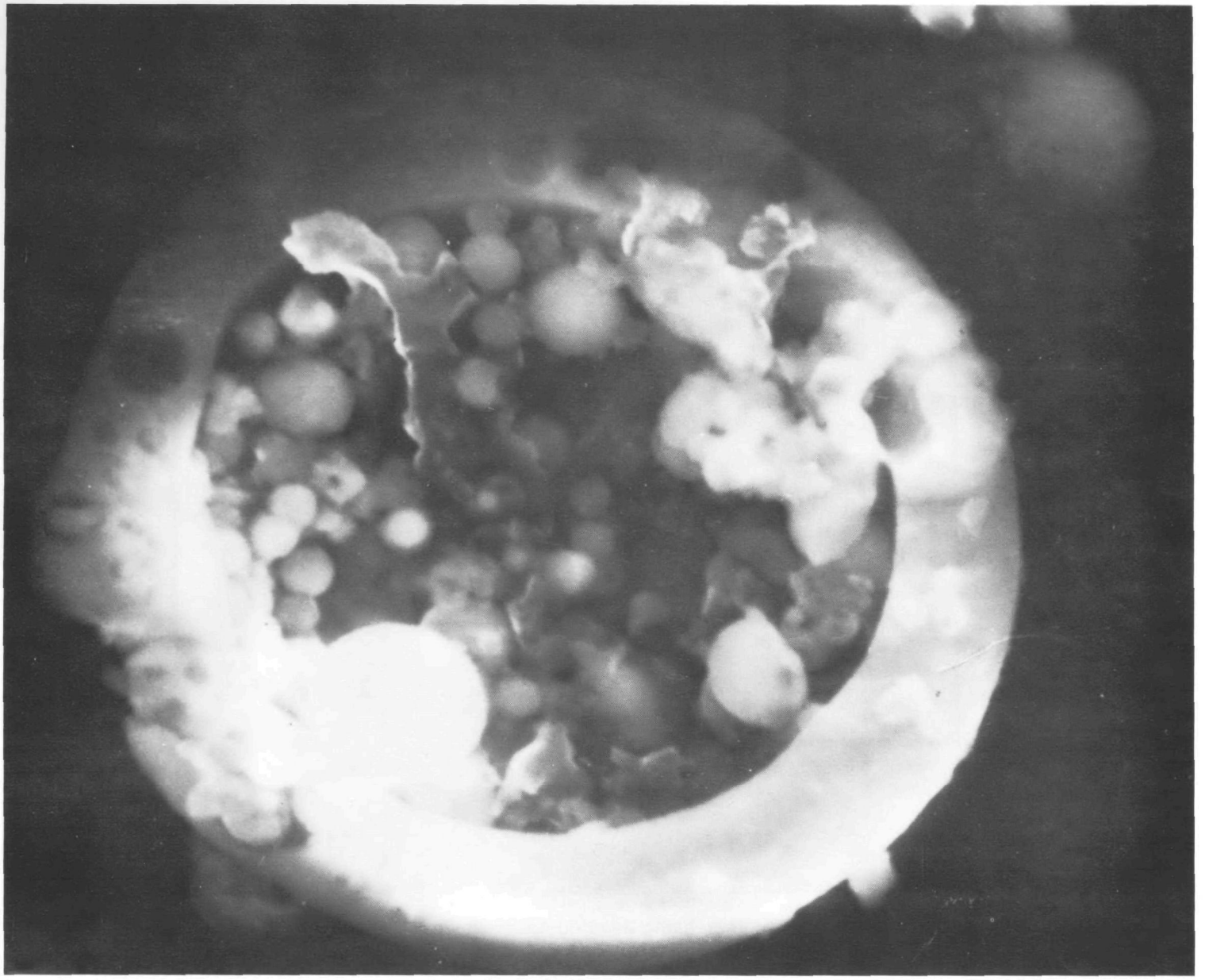
Standards and control technologies based on a holistic examination of combustion processes and emissions, of their effects on human health and the environment, and of energy and economic costs and impacts.

THE PURPOSE OF THE CCEA PROGRAM

Fossil-fuel-fired electric power generating station.

The increasing demand for energy in the United States is projected to be met in part by a significant increase in fossil fuel combustion. The environmental penalties associated with fossil fuel combustion include air pollution, water contamination, and land degradation. Pollutant transformation, synergistic interaction between two or more pollutants, and potential solutions often generate still other undesired effects. Considerable research to identify and evaluate environmental impacts and to develop control methods has been conducted by a wide variety of private and government organizations. More often than not, these studies have had specific and, therefore, limited objectives; coordination and information exchange between efforts has also been limited.

Recognizing that a comprehensive program was needed to provide information on combustion-related environmental impacts, the EPA Industrial Environmental Research Laboratory (IERL-RTP) in Research Triangle Park, North Carolina, initiated the Conventional Combustion Environmental Assessment (CCEA) Program in February 1977. The primary purpose of the Program is to assess the environmental, economic, and energy impacts of stationary conventional combustion processes in order to define specific recommendations for control technology and control standards development. The CCEA Program will provide valuable information and data for technological and managerial decision-makers who are responsible for the continued and expanded use of conventional combustion processes at reasonable environmental, economic, and energy costs.



Electron microscopy, used in the CCEA Program, allows detailed inspection of coal fly ash particles.

The CCEA Program addresses the full range of impacts that stationary conventional combustion processes (utility, industrial, commercial, and residential) and associated control equipment have on the environment. The CCEA Program includes consideration of the combustion process, combustion-related emissions (gaseous, liquid, and solid waste), health effects, ecological impacts, existing and future environmental goals and objectives (including standards and regulations), projected process use, total pollutant load estimations, and available control alternatives.

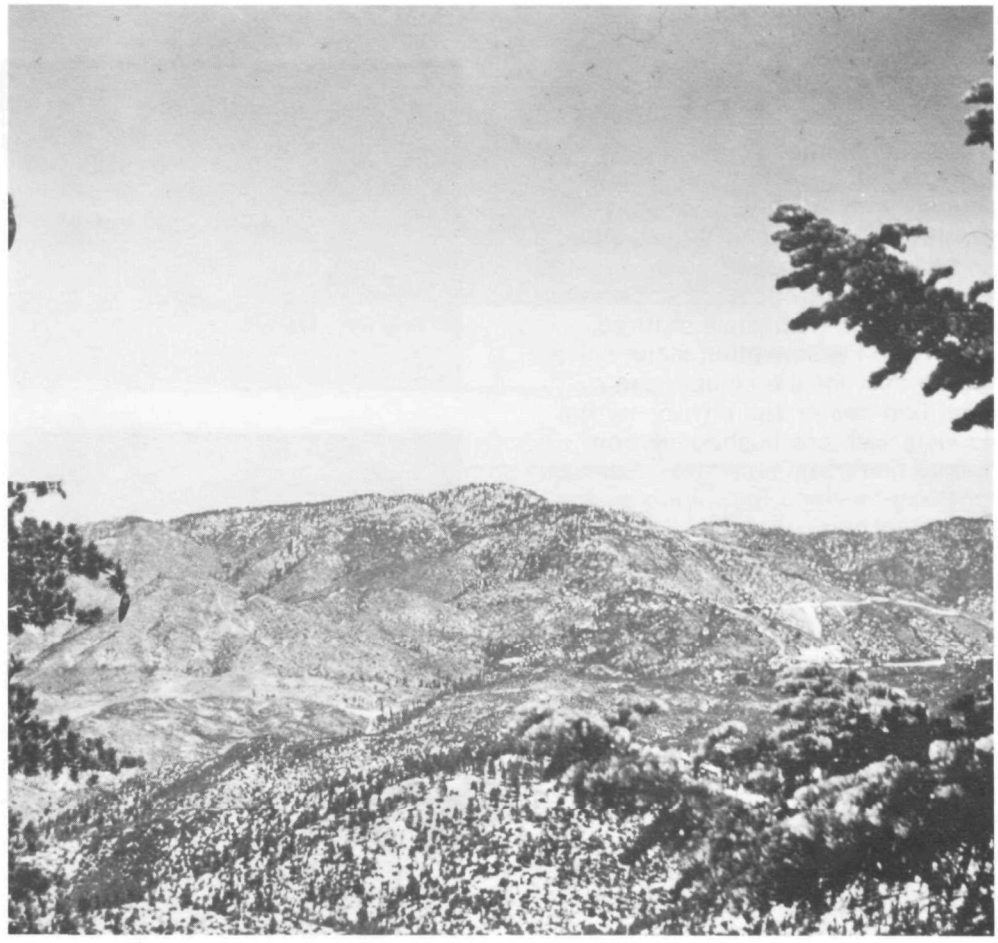
CONSOLIDATE CCEA INFORMATION INTO A SYSTEMATIC, INTEGRATED DATA BASE

The focal point of the CCEA Program is the CCEA Methodology. This Methodology provides a systematic approach for compiling information and data describing the effects of combustion-related emissions, and for the comparison of these effects with acceptable environmental goals and objectives. Specific recommendations for standards and control technology development result from this Methodology.

COMPILE INFORMATION DESCRIBING CCEA-RELATED RESEARCH

The CCEA Program also compiles information describing the hundreds of completed and ongoing CCEA-related studies. This activity, which uses a specially developed program matrix approach, defines exactly the research that has been or is being conducted and, thus, identifies the areas where additional research is needed. The resulting data base, planned as a tool for energy and environmental decision-makers, should help to reduce duplication of research efforts and increase the return from available resources.

The CCEA Program also includes identification of health and ecological impacts...



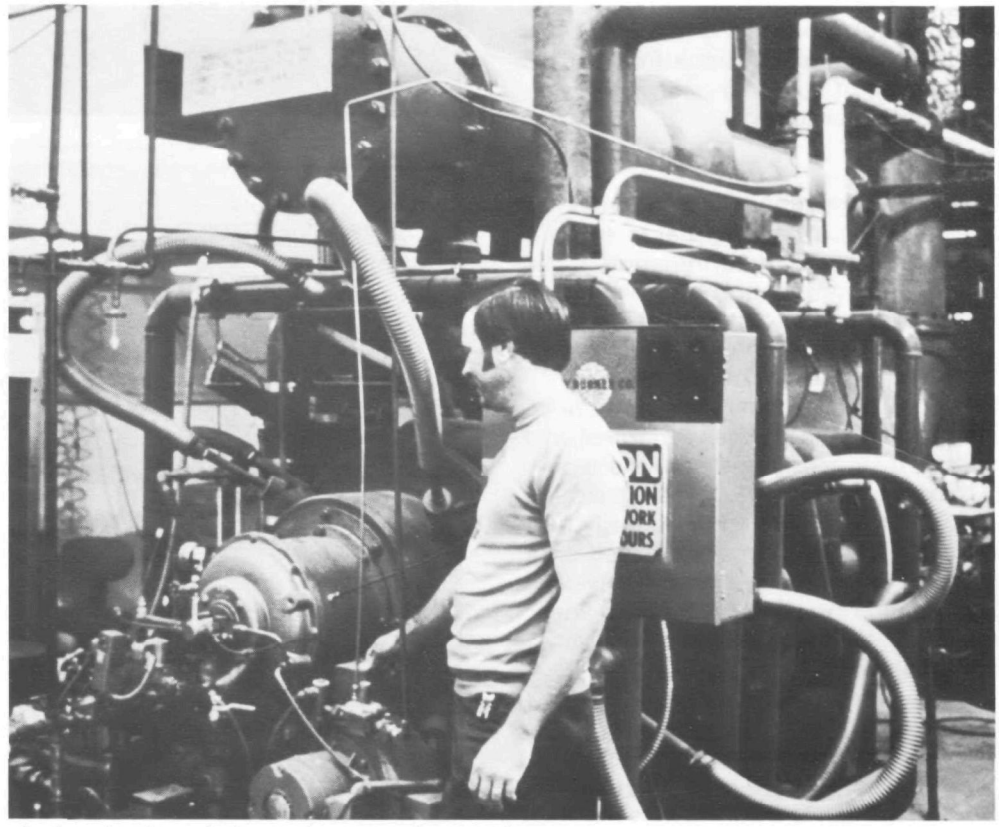
Development of environmental goals and objectives...

MANAGE CCEA-RELATED RESEARCH PROJECTS

Management of CCEA-related research efforts is also a function of the CCEA Program. Four projects that are ongoing within IERL-RTP have been incorporated into the Program. As resources allow, additional projects will be conducted to acquire information needed to complete assessments.

TRANSFER ACQUIRED INFORMATION TO POTENTIAL USERS

The CCEA Program involves the acquisition and analysis of a substantial amount of information. Dissemination of this information to a broad audience of potential users will be accomplished through numerous mechanisms including technical reports, briefings and conferences, and annual CCEA symposia.



And evaluation of alternative control strategies.

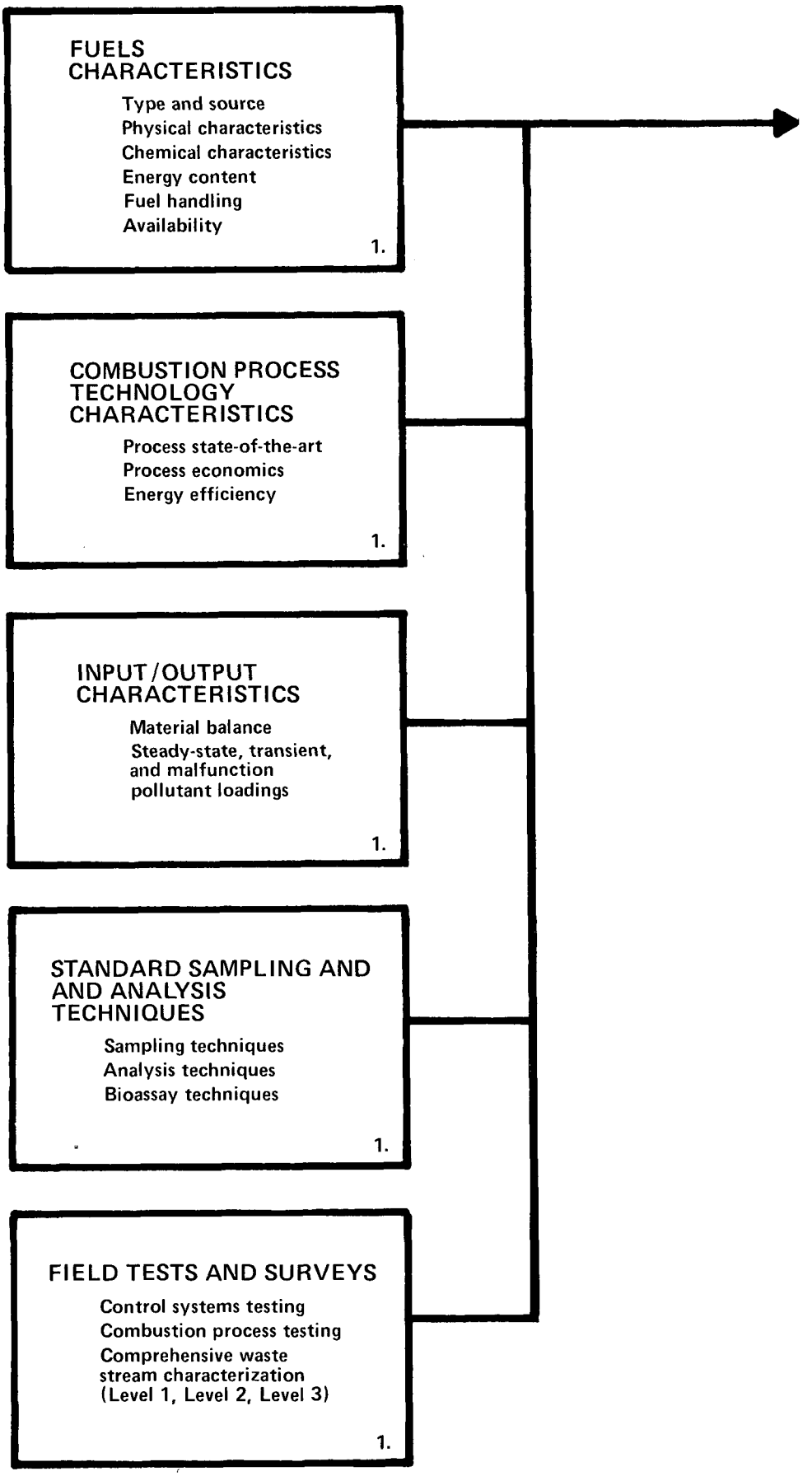
The CCEA Methodology is an iterative process that is carried out simultaneously with technology development to identify and evaluate the full range of impacts of combustion processes and associated control equipment on the environment. It consists of three information assimilation steps and a mechanism for the comparison of identified health and environmental impacts with established environmental goals and objectives. Specific recommendations for standards and control technology development result from this methodology.

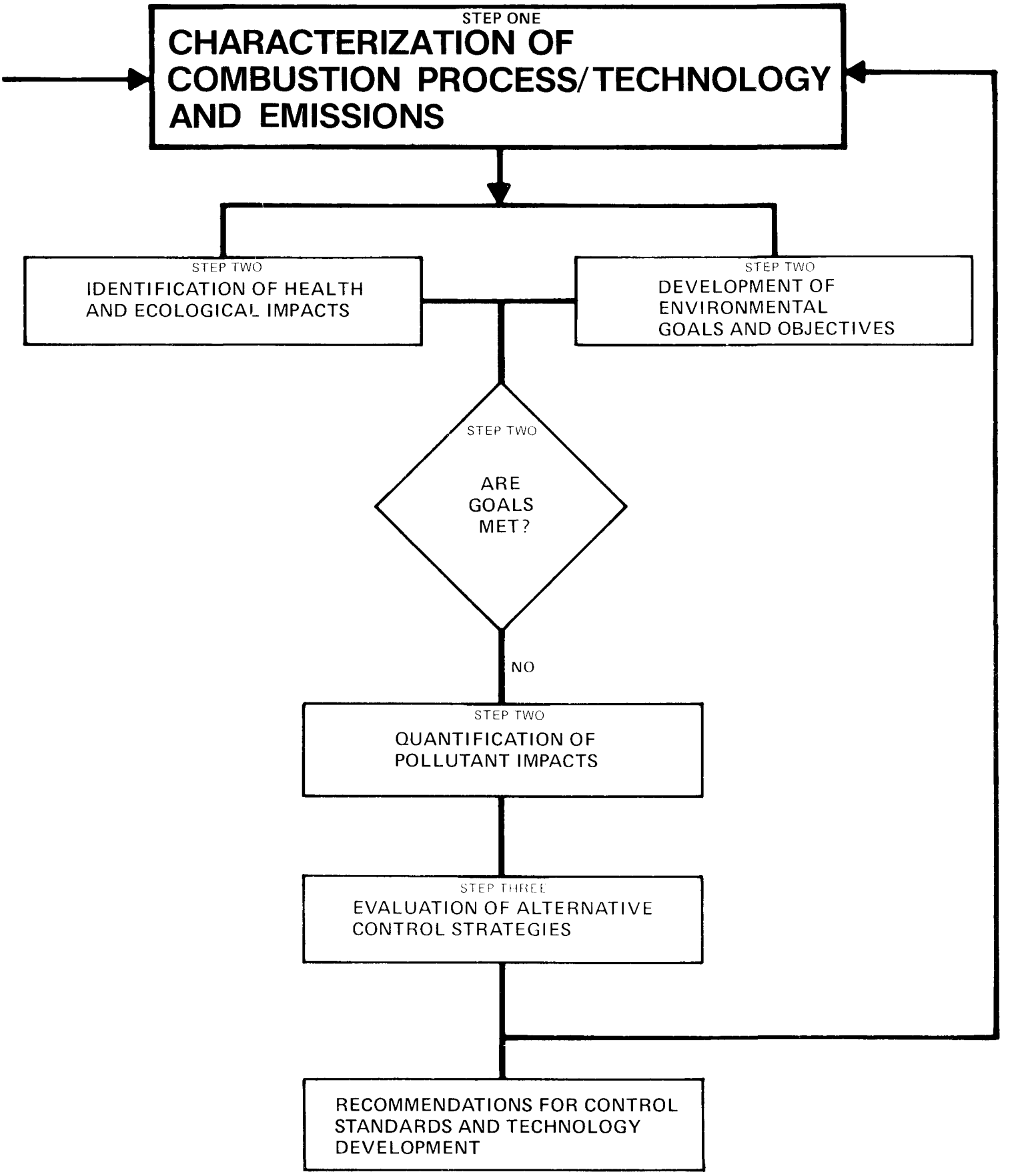
STEP ONE

Characterization of the Combustion Process/Technology and its Emissions is Step One in CCEA. The objectives of this Step are to: (1) develop a comprehensive base of available data on combustion-related pollutants; (2) obtain new data from field tests to fill identified data gaps; (3) examime existing sampling and analysis methods and, if necessary, recommend additional development; and (4) characterize emissions/effluents from each major type of stationary conventional combustion process.

The Characterization Step includes identification of the pollutants emitted from the process, determination of the quantities emitted, and establishment of the properties of the emissions. Detailed information on fuels, process technologies, input/output characteristics (that establish the relationships among the process variables), and standard sampling and analysis techniques are accumulated. Field tests and surveys are conducted to quantify and characterize the emissions based on a detailed, phased-screening, analysis and monitoring protocol that provides three levels of waste stream characterization.

The information and data collected in Step One serve as an input to Step Two, Health and Ecological Impacts Assessment.



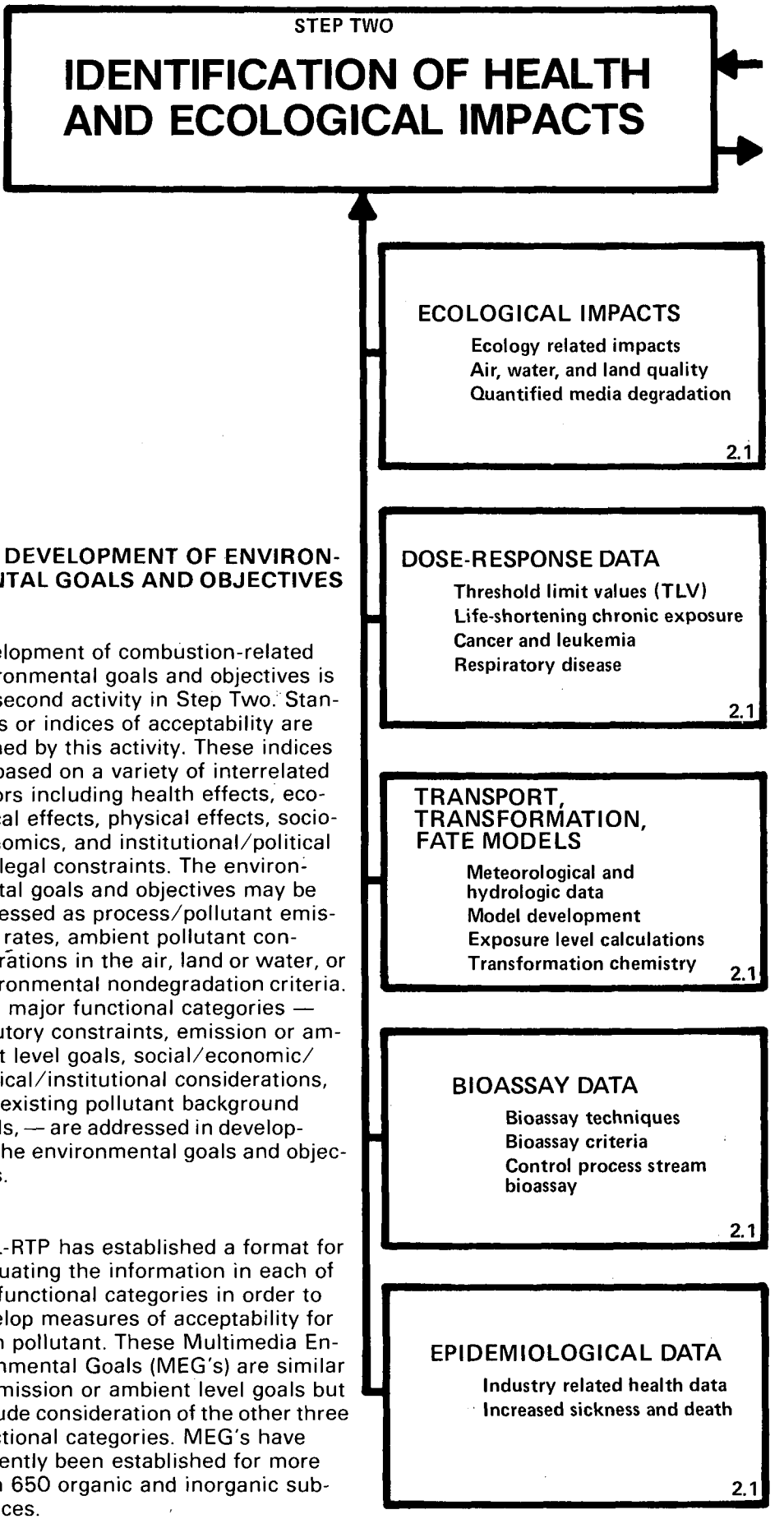

STEP ONE
CHARACTERIZATION OF COMBUSTION PROCESS/TECHNOLOGY AND EMISSIONS
STEP TWO
IDENTIFICATION OF HEALTH AND ECOLOGICAL IMPACTS
STEP TWO
DEVELOPMENT OF ENVIRONMENTAL GOALS AND OBJECTIVES
STEP TWO
ARE GOALS MET?
NO
STEP TWO
QUANTIFICATION OF POLLUTANT IMPACTS
STEP THREE
EVALUATION OF ALTERNATIVE CONTROL STRATEGIES
RECOMMENDATIONS FOR CONTROL STANDARDS AND TECHNOLOGY DEVELOPMENT

STEP TWO

Step Two establishes the impacts of pollutants identified in Step One and results in the evaluation of alternative control strategies (Step Three) and/or recommendations for standards development or modifications. Assessment of the health and ecological impacts of the combustion process and its emissions includes (1) identification of health and ecological impacts; (2) development of environmental goals and objectives; and (3) quantification of pollution impacts. A comparison mechanism to ascertain whether the identified health and ecological impacts are acceptable by current environmental goals and objectives is also included in Step Two.

2.1. IDENTIFICATION OF HEALTH AND ECOLOGICAL IMPACTS

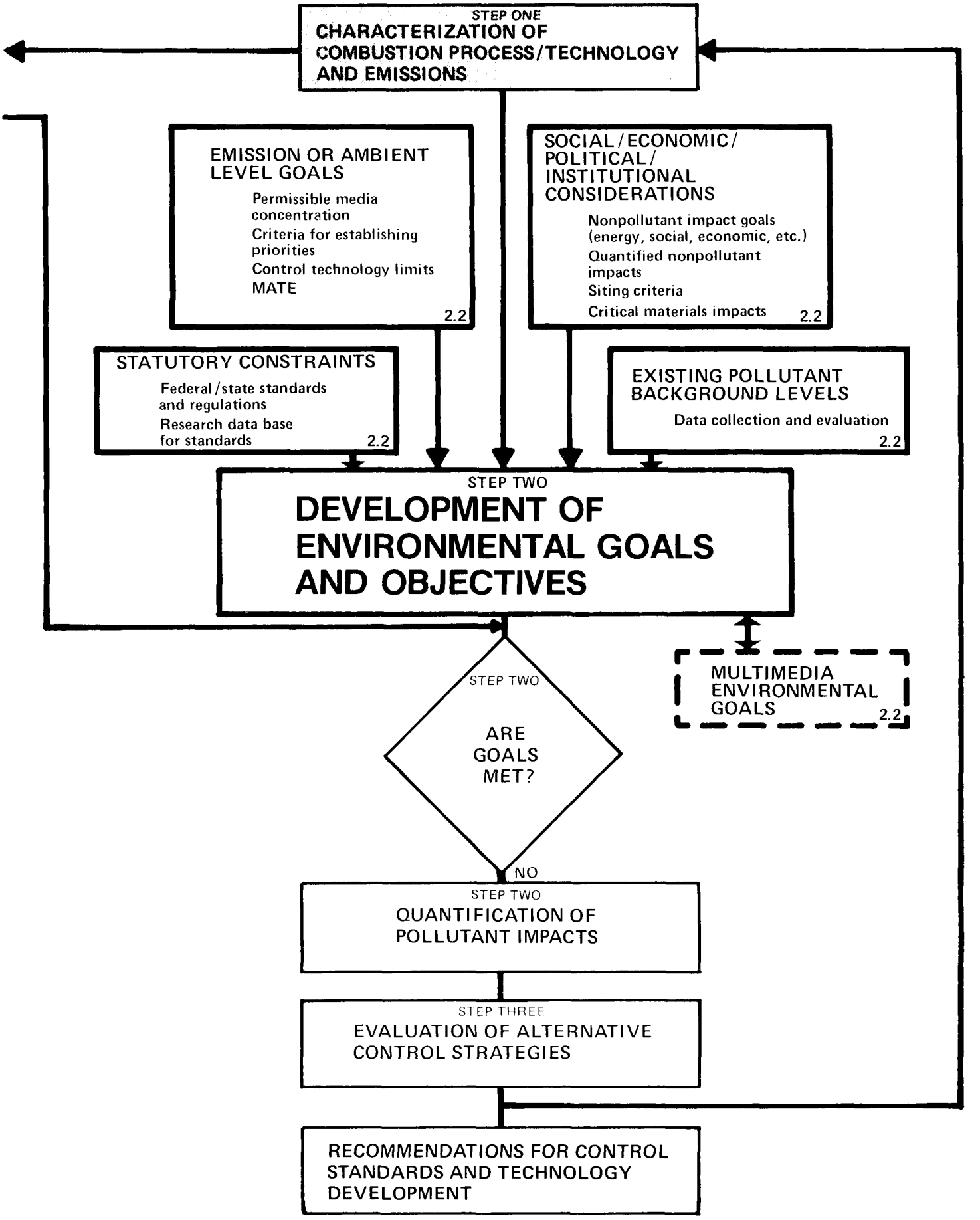
Identification of the health and ecological impacts of the combustion process includes detailed analyses of the response of the environment and of the exposed population to the process pollutants. Data and analyses relating to the air, water and land quality, ecology-related effects, increased morbidity and mortality rates, and quantified media degradation alternatives are compiled. This information is acquired from Step One and the following activities: (1) identification of ecological impacts to quantify such concepts as media degradation; (2) evaluation of dose-response data to translate environmental pollutant concentrations into an estimate of the number and type of specific biological impacts to be expected in an exposed population; consideration of chronic or acute responses such as cancer, leukemia, and respiratory disease; (3) application of pollutant transport, transformation, and fate models to calculate pollutant concentrations and exposure levels; (4) bioassays to identify the effects of varying concentrations of pollutants on living organisms; and, (5) development of epidemiological data from occupational exposure-related health information.

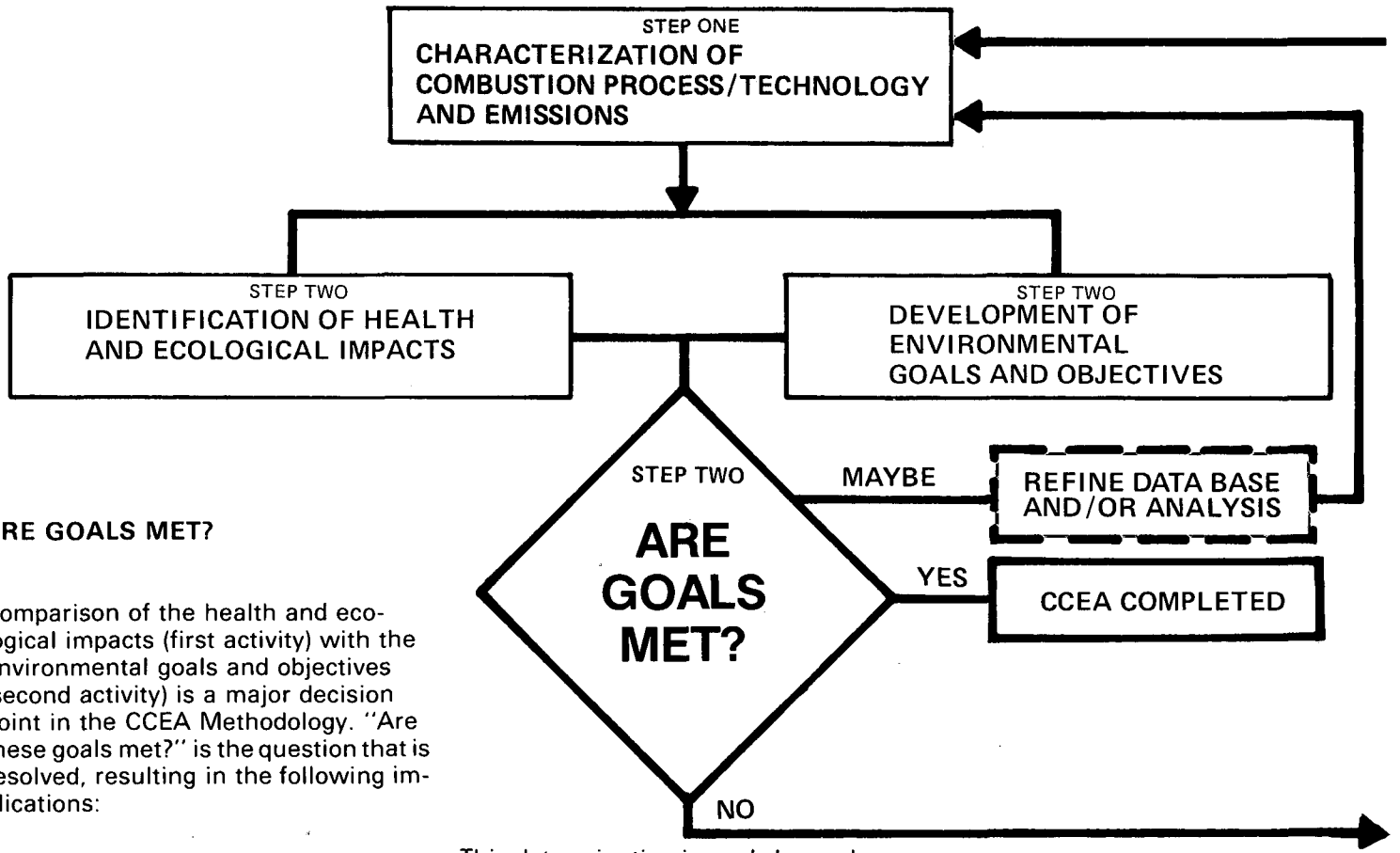


2.2. DEVELOPMENT OF ENVIRONMENTAL GOALS AND OBJECTIVES

Development of combustion-related environmental goals and objectives is the second activity in Step Two. Standards or indices of acceptability are defined by this activity. These indices are based on a variety of interrelated factors including health effects, ecological effects, physical effects, socioeconomics, and institutional/political and legal constraints. The environmental goals and objectives may be expressed as process/pollutant emission rates, ambient pollutant concentrations in the air, land or water, or environmental nondegradation criteria. Four major functional categories — statutory constraints, emission or ambient level goals, social/economic/political/institutional considerations, and existing pollutant background levels, — are addressed in developing the environmental goals and objectives.

IERL-RTP has established a format for evaluating the information in each of the functional categories in order to develop measures of acceptability for each pollutant. These Multimedia Environmental Goals (MEG's) are similar to emission or ambient level goals but include consideration of the other three functional categories. MEG's have currently been established for more than 650 organic and inorganic substances.


STEP ONE
CHARACTERIZATION OF COMBUSTION PROCESS/TECHNOLOGY AND EMISSIONS
EMISSION OR AMBIENT LEVEL GOALS
Permissible media concentration
Criteria for establishing priorities
Control technology limits
MATE
2.2
SOCIAL/ECONOMIC/ POLITICAL/ INSTITUTIONAL CONSIDERATIONS
Nonpollutant impact goals (energy, social, economic, etc.)
Quantified nonpollutant impacts
Siting criteria
Critical materials impacts
2.2
STATUTORY CONSTRAINTS
Federal/state standards and regulations
Research data base for standards
2.2
EXISTING POLLUTANT BACKGROUND LEVELS
Data collection and evaluation
2.2
STEP TWO
DEVELOPMENT OF ENVIRONMENTAL GOALS AND OBJECTIVES
MULTIMEDIA ENVIRONMENTAL GOALS
2.2
STEP TWO
ARE GOALS MET?
NO
STEP TWO
QUANTIFICATION OF POLLUTANT IMPACTS
STEP THREE
EVALUATION OF ALTERNATIVE CONTROL STRATEGIES
RECOMMENDATIONS FOR CONTROL STANDARDS AND TECHNOLOGY DEVELOPMENT



ARE GOALS MET?

Comparison of the health and ecological impacts (first activity) with the environmental goals and objectives (second activity) is a major decision point in the CCEA Methodology. "Are these goals met?" is the question that is resolved, resulting in the following implications:

The health and ecological impacts are acceptable by current goals and objectives, therefore the environmental assessment is complete.

The acceptability of the impacts are questionable due to insufficient or unreliable data, therefore data refinement and reevaluation are necessary to draw conclusions.

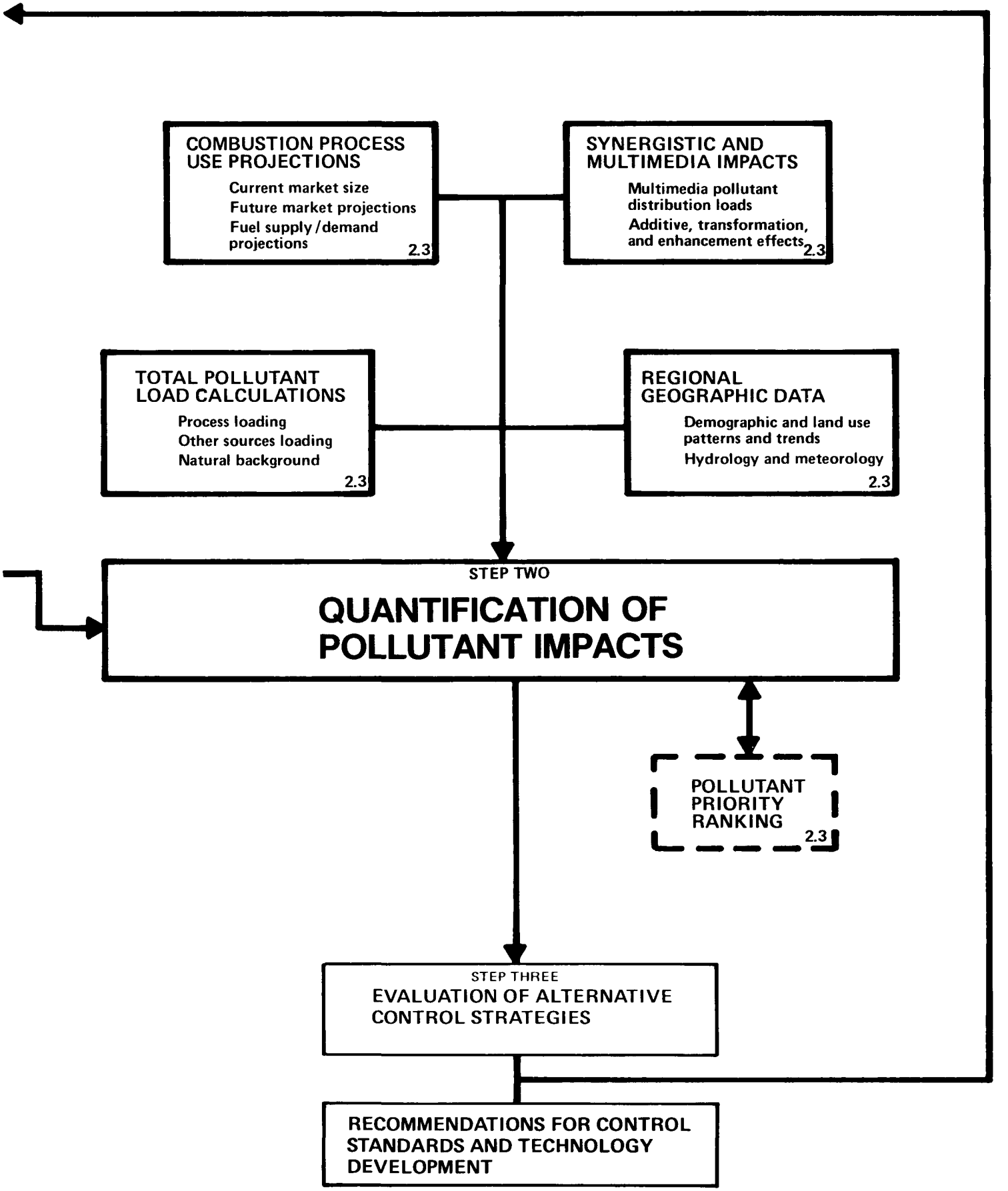
The impacts of the combustion process and its emissions are unacceptable according to current environmental goals and objectives, therefore the impacts must be quantified and methods to ameliorate or control the impacts must be identified.

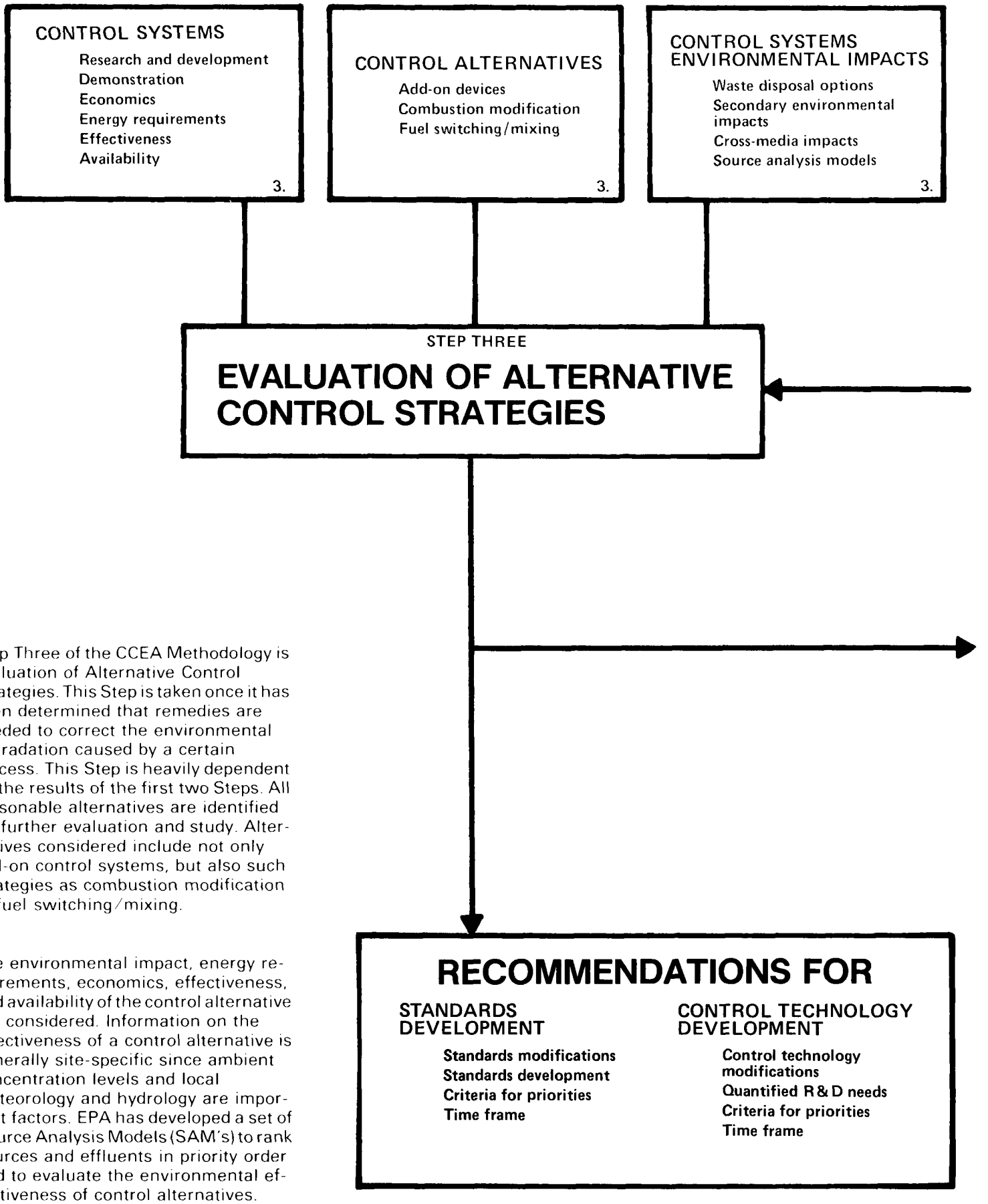
2.3. QUANTIFICATION OF POLLUTANT IMPACTS

The third activity of Step Two is conducted following the determination that the impacts of the combustion process and its emissions are unacceptable.

This determination is made by analyses of studies that (1) establish combustion process use projections to determine the distribution of the combustion process now and in the future; (2) identify synergistic and multimedia impacts, including atmospheric transformation, leaching, and additive transformation or enhancement effects of two or more pollutants; (3) develop total pollutant load calculations that reflect the amount of pollutant to be expected to occur in the atmosphere due to the pertinent combustion source, other man-made sources, and natural background; and (4) evaluate regional geographic data, including regional population growth projections, and local hydrology and meteorology, in terms of regional total pollution load and health effects data.

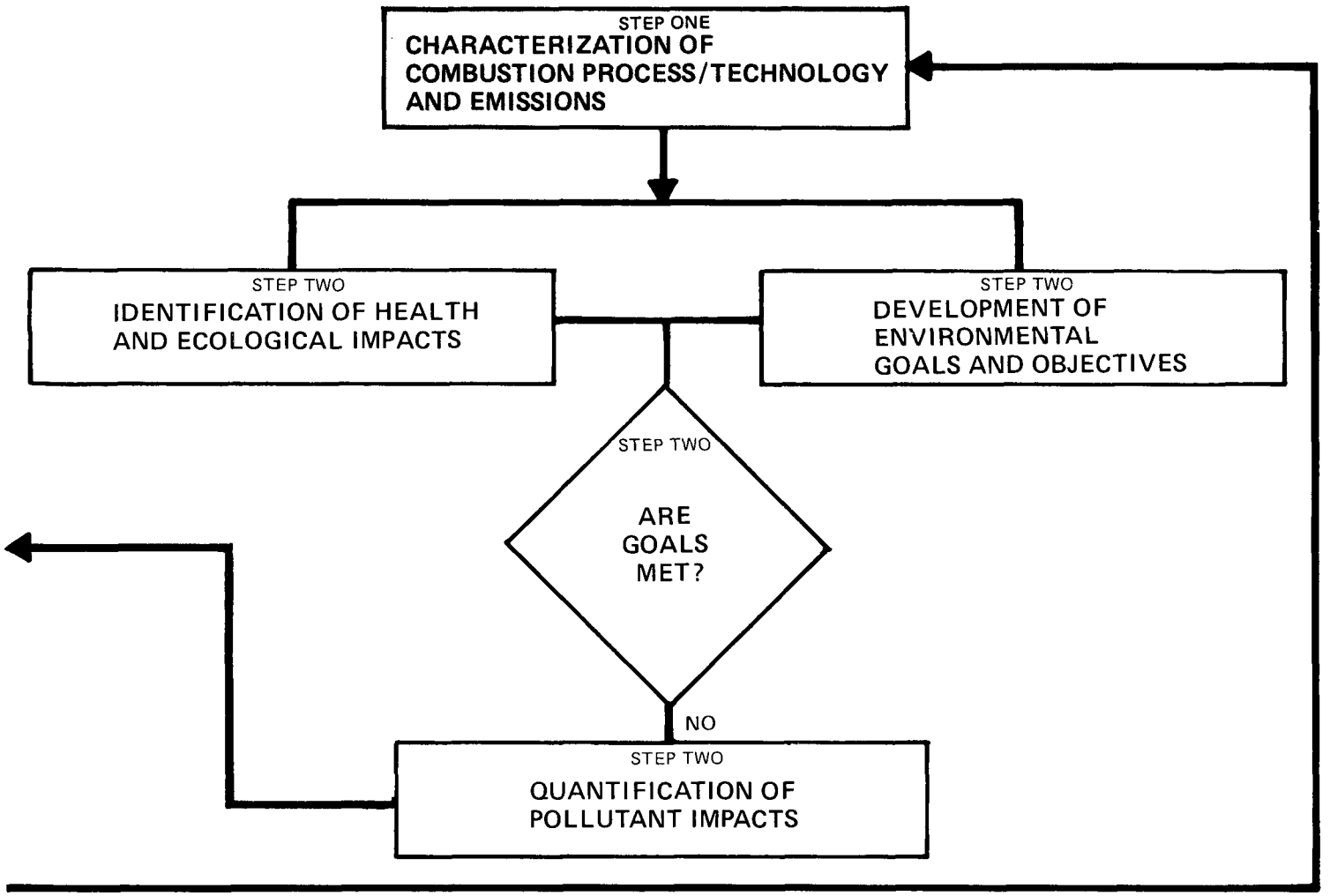
This quantification effort results in pollutant priority rankings based on the above data and degree of hazard calculations. This ranking will reflect the significance of the health and ecological impacts, as well as identify areas where information is lacking, and will aid in identifying standards or pollution control technology needs.


COMBUSTION PROCESS USE PROJECTIONS
Current market size
Future market projections
Fuel supply/demand projections
2.3
SYNERGISTIC AND MULTIMEDIA IMPACTS
Multimedia pollutant distribution loads
Additive, transformation, and enhancement effects
2.3
TOTAL POLLUTANT LOAD CALCULATIONS
Process loading
Other sources loading
Natural background
2.3
REGIONAL GEOGRAPHIC DATA
Demographic and land use patterns and trends
Hydrology and meteorology
2.3
STEP TWO
QUANTIFICATION OF POLLUTANT IMPACTS
POLLUTANT PRIORITY RANKING
2.3
STEP THREE
EVALUATION OF ALTERNATIVE CONTROL STRATEGIES
RECOMMENDATIONS FOR CONTROL STANDARDS AND TECHNOLOGY DEVELOPMENT



Step Three of the CCEA Methodology is Evaluation of Alternative Control Strategies. This Step is taken once it has been determined that remedies are needed to correct the environmental degradation caused by a certain process. This Step is heavily dependent on the results of the first two Steps. All reasonable alternatives are identified for further evaluation and study. Alternatives considered include not only add-on control systems, but also such strategies as combustion modification or fuel switching/mixing.

The environmental impact, energy requirements, economics, effectiveness, and availability of the control alternative are considered. Information on the effectiveness of a control alternative is generally site-specific since ambient concentration levels and local meteorology and hydrology are important factors. EPA has developed a set of Source Analysis Models (SAM's) to rank sources and effluents in priority order and to evaluate the environmental effectiveness of control alternatives.



THE CCEA METHODOLOGY IS AN ITERATIVE PROCEDURE

Once a control alternative is identified for a given combustion process, the environmental assessment is repeated. Ideally, the methodology is repeated until all impacts on health and the ecology caused by the combustion process fall within the acceptable limits of current environmental goals and objectives.

Specific recommendations for the promulgation of stricter environmental standards and/or for the development of additional control technologies are made if the impacts are serious or if optimum existing technologies are inadequate. These recommendations fulfill the primary purpose of the CCEA Program.

Standards Development Recommendations are made when the impacts of the combustion process or its emissions on human health or the ecology are serious and no Government standards exist to control these impacts or existing standards are inadequate. Recommendations for standards development or modification are ranked in order of priority and are justified by specific data. Information on the degree of control desired and a time frame for promulgation accompany these recommendations.

Control Technology Development Recommendations are made when existing or developmental alternatives for controlling adverse environmental impacts are inadequate. These recommendations are quantified and ranked in priority order for consideration by technological and managerial decision-makers. The priority recommendations are justified on engineering and environmental bases and include information on the degrees of control required, additional research and development requirements, developmental cost estimates, and projected developmental schedules.

THE CCEA PROGRAM MATRIX

In addition to providing the recommendations resulting from the CCEA Methodology, the CCEA Program also seeks to provide information that will allow the most efficient use of the resources available to investigate combustion-related pollution. To meet this goal, a CCEA Program Matrix was developed to compare and integrate information pertaining to past, ongoing, and planned CCEA-related research.

This Matrix delineates the objective(s) of each study by codes that describe (1) type of fuel, 13 categories; (2) use sector, 4 categories including utility and industry; (3) combustion process/technology, 15 categories; (4) pollution control technology, 47 categories; (5) media, i.e., air, water, or land; (6) environmental assessment elements, 72 elements to define whether the study addresses fuels, control alternatives, health effects, etc.; and (7) pollutants addressed, 14 categories including sulfur oxides, particulates, organics, thermal, and ions.

Program matrices have been developed for a selected set of core studies. This preliminary information base will provide the foundation upon which a more complete CCEA matrix will be built. This comprehensive, easily accessed reference list of past and current CCEA research will facilitate planning by identifying important areas where no studies are being conducted. Complementary efforts being conducted by different organizations will also be identified so that results can be integrated and studies will not be duplicated

One of the purposes of the CCEA Program is to provide coordination among individual research efforts to ensure that information pertinent to high priority assessments is or soon will be available. Inherent in the achievement of this purpose is the CCEA Program Matrix which will provide management outside of IERL-RTP the information needed to identify the research that is ongoing or planned, the data and information from other studies that could be integrated into planned research efforts, and the areas where additional research is needed.

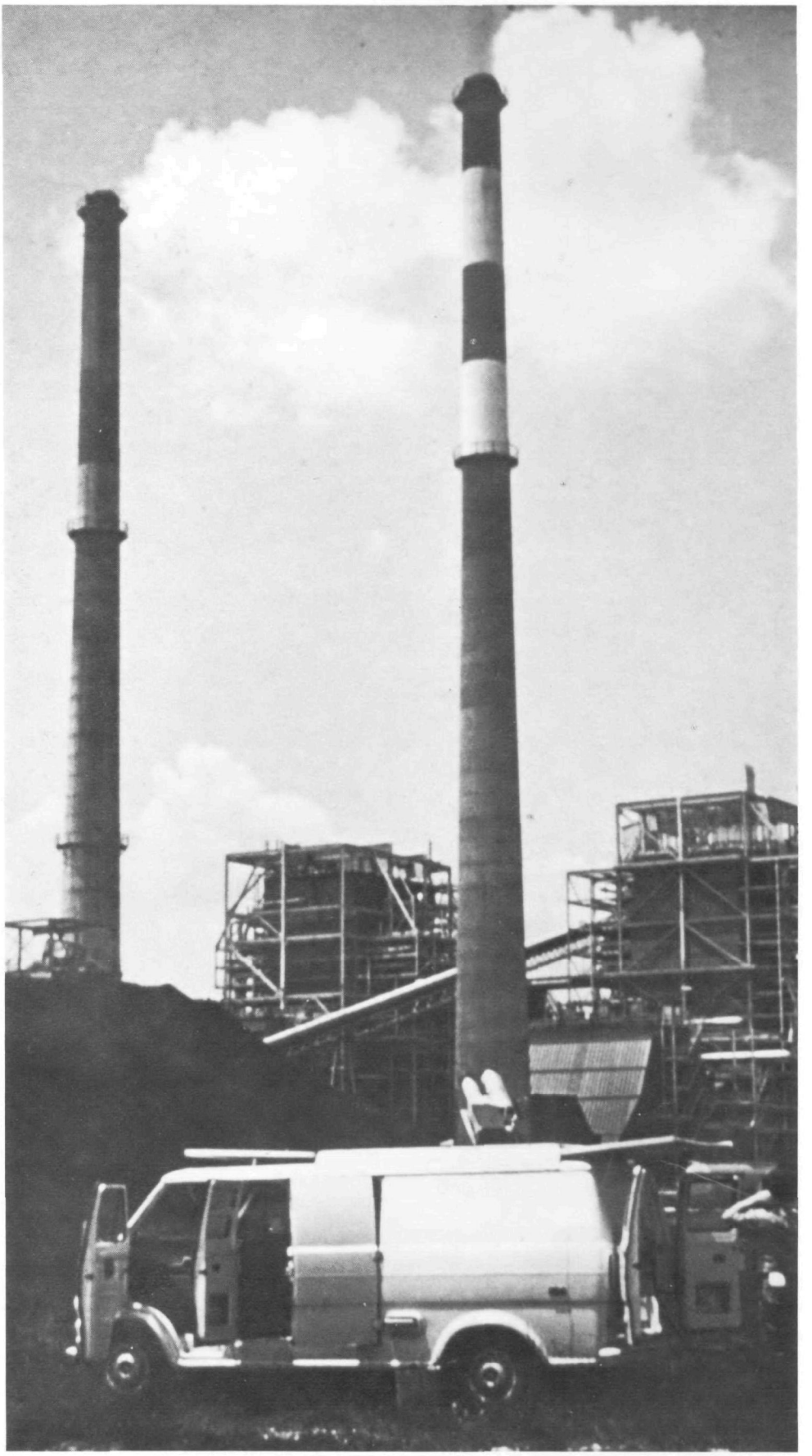
The outputs from the CCEA Program Matrix will provide identical input to IERL-RTP management; but, within the Laboratory, integrated and coordinated management of CCEA-related projects and available funding will help to ensure that the objectives of CCEA are met in the most timely and efficient manner. To date, four CCEA-related projects have been incorporated into the CCEA Program. These ongoing IERL-RTP studies, which were included in the original set of Program Matrix core studies, are:

Characterization of Emissions from Conventional Combustion, which provides a systematic characterization of emissions from conventional combustion processes,

Environmental Assessment of Combustion Processes Modified for NO_x Control, which provides comprehensive information on the impacts of combustion control technologies,

Environmental Assessment of Residual Oil Processing, which involves environmental assessment of residual oil/derivatives utilized in conventional combustion processes, and

Environmental Assessment of Waste (Liquid and Solid) Streams, which characterizes the liquid and solid streams from combustion processes and control technologies.



Research conducted by the CCEA Program will help to fill the gaps in available conventional combustion data and information.

The CCEA Program will result in the acquisition of a substantial information base, in numerous analyses of the collected information, and in specific recommendations based on these analyses. This information and technical data must be communicated to a broad audience of potential users if the CCEA Program is to be effective in directing combustion-related research and development onto a course compatible with reconciling the harmful effects of combustion processes with acceptable environmental goals and objectives.

To accomplish the needed information transfer, IERL-RTP will publish annual reports on the status of the CCEA Program and technical reports on results of individual CCEA projects. Status briefings, conferences, and annual symposia will also contribute to this transfer objective. The first annual symposium will be held in Denver, Colorado, October 2-5, 1979.

For additional information on the CCEA Program, contact:

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