

THE AUTOMOBILE & AIR POLLUTION:

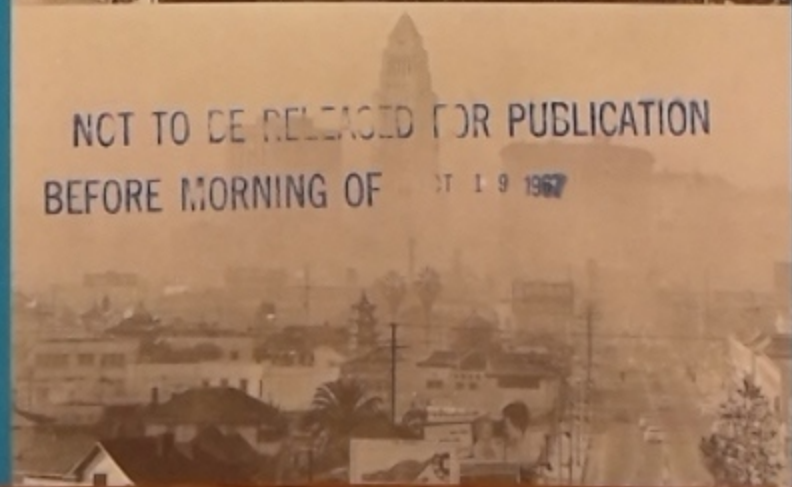
A PROGRAM FOR PROGRESS

Part I

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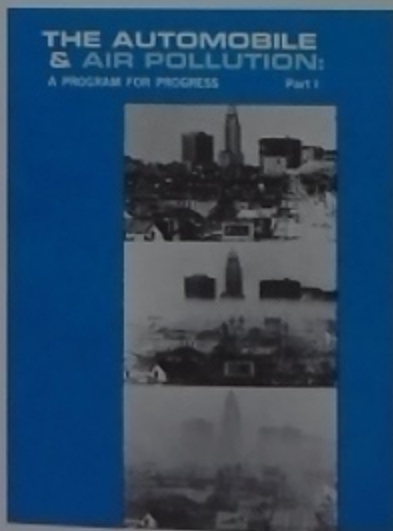
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BEFORE MORNING OF OCT 19 1967



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The three pictures of downtown Los Angeles include a clear day (top), pollution trapped beneath an inversion layer at 250 feet (middle), and pollution distribution under an inversion layer at 1500 feet (bottom).

Source: Los Angeles Air Pollution Control District

THE AUTOMOBILE AND AIR POLLUTION:

A Program for Progress

**Report
of the
Panel on Electrically Powered Vehicles**

to the
Commerce Technical Advisory Board
John F. Kincaid, Chairman
Assistant Secretary for Science and Technology



**U.S. DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary**

October, 1967

Letter of Transmittal

To: The Honorable Robert S. McNamara, Secretary of Defense
 The Honorable Lawrence F. O'Brien, Postmaster General
 The Honorable Stewart L. Udall, Secretary of the Interior
 The Honorable Alexander B. Trowbridge, Secretary of Commerce
 The Honorable John W. Gardner, Secretary of Health, Education, and Welfare
 The Honorable Robert C. Weaver, Secretary of Housing and Urban Development
 The Honorable Alan S. Boyd, Secretary of Transportation
 The Honorable Glenn T. Seaborg, Chairman of the Atomic Energy Commission
 The Honorable Lee C. White, Chairman of the Federal Power Commission

The enclosed report of the Panel on Electrically Powered Vehicles represents our best appraisal of the complex problem of automotive transportation in relation to the current and critical problem of air pollution.

In this era of rapidly changing technology, it is obviously impossible to accurately forecast future scientific, economic, and social developments or to be aware of all worldwide research activities. The Panel has attempted to provide analysis and recommendations which can serve as a basis for immediate action.

This study has drawn upon the talents and energies of hundreds of individuals and dozens of industrial, government, and academic organizations. Without exception, requests for assistance have been received with complete cooperation and concern for the public good, and work has been performed with competence and dispatch. Completion of the research and analysis phase of our study in less than seven months after formation of the Panel would have been impossible without such a dedicated response.

Special acknowledgement is due those experts who have been members of the Panel and the six subpanels which studied selected aspects of the problem in depth. These men served without compensation and have taken time from their busy schedules, evenings, holidays and weekends to accomplish their assignments in remarkably short time. The subpanel studies, published as Part II of this report, have been an indispensable component of this project and have served as a basis for the findings and recommendations of the Panel.

Respectfully submitted,

Richard S. Morse

Richard S. Morse, Chairman
 Panel on Electrically Powered Vehicles

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 University of

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PANEL ON ELECTRICALLY POWERED VEHICLES

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Edwin A. Gee, Director, Development Department, E. I. duPont de Nemours & Co., served as a member of this Panel until his resignation on September 7, 1967.

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SUMMARY OF FINDINGS

I. The Relation of Automotive Emissions to the Nation's Air Pollution Problem

1. Air pollution presents a serious threat of increasing significance to the health and welfare of this country and all industrialized areas of the world. Without prompt and effective action to control this contamination of the atmosphere, living conditions within and around the cities of the Nation will continue to deteriorate. Automotive vehicle emissions, namely carbon monoxide, hydrocarbons, oxides of nitrogen, and lead compounds, are a principal contributor to this problem.

2. Emissions from automotive vehicles are largely responsible for the formation of photochemical smog in Los Angeles and some other areas, and vehicles are the principal source of carbon monoxide in the atmosphere. In addition to these known, specific effects, vehicle emissions combine with emissions from other sources, in ways and to an extent unknown, to contribute to general air pollution.

3. While there is evidence establishing ill effects from aggregate air pollution, there is an urgent need for more extensive information regarding the significance of specific and combined air pollutants on public health.

4. Population increase and urbanization trends require an overall national strategy for the control of all forms of air pollution and the early and effective implementation of emission standards to meet air quality goals. Local, state, and Federal agencies responsible for urban transportation systems have given inadequate consideration to pollution implications in the development of transportation systems.

5. The magnitude of expected future need for urban-suburban personal transportation requires the early development of virtually non-polluting transportation systems. The use of mass transportation systems can be a factor in the reduction of air pollution.

II. Technology and the Control of Air Pollution

1. On the basis of current technology, it will be commercially feasible during the next decade to reduce exhaust emissions from new gasoline internal combustion engines to values at least as low as:

- Hydrocarbons—50 parts per million (900 ppm)*
- Carbon monoxide—.5% (3.5%)
- Oxides of nitrogen—250 parts per million (1500 ppm)

2. During the next decade, in the normal course of events, no significant reduction in total air pollution will be achieved through the introduc-

* Estimated levels for uncontrolled vehicles.

tion of unconventional low-polluting vehicles into the current population of approximately 90 million vehicles.

- (a) The state of technology does not permit the current development of an economically feasible electric car except for special-purpose, limited-range use.
 - (b) Current research activities indicate that significant technical advances may be expected in the development of improved electric energy storage and conversion devices. The time anticipated for the development and commercialization of such devices will not allow their use in a significant number of vehicles in the next decade. Any acceleration of this technology to make earlier commercialization possible will be helpful in controlling urban air pollution.
 - (c) Gas turbines are reasonable alternatives to internal combustion engines in the large sizes used in trucks, trains, and buses, but are not now economically feasible in the smaller units required for automobiles. Gas turbines produce low hydrocarbon and carbon monoxide emissions, and can be designed to yield low nitrogen oxide emissions.
 - (d) Hybrid power plants involving combinations of high energy devices and high power devices could have satisfactory performance, but their economic feasibility for private passenger automobiles has not been established.
3. Vehicles using external combustion engines for propulsion, such as the piston-type steam engine of advanced design, potentially offer a satisfactory alternative to the present automobile and should have very low pollution and noise characteristics.
 4. Diesel engines in trucks and buses emit highly undesirable smoke and odor, in addition to other pollutants. Smoke can be controlled now with proper maintenance and operation and the odor problem can probably be solved with adequate research.
 5. Adequate energy sources are available at least for the remainder of this century to meet the vehicle transportation requirements of the country regardless of the type of power plant that may be used.
 6. Over the next thirty years, the introduction and widespread use of any currently proposed propulsion systems will not be restricted by the supply of materials, with the possible exception of those which require large amounts of cadmium, platinum group metals, or silver.

III. The Role of Industry

1. There has been inadequate incentive for an individual automotive manufacturer to apply pollution control technology to the automobile in advance of its competitors.
2. There has been inadequate incentive for an individual fuel producer to introduce products with improved pollution characteristics in advance of its competitors.

3. The automotive and petroleum industries clearly recognize that Government has the primary responsibility to determine the effects of pollution and to establish realistic air quality goals and nationwide standards for automotive emissions.

4. The effective reduction of air pollution requires cooperation among automotive manufacturers, fuel producers, and the government at Federal, state, and local levels, as well as a clear understanding by all of their roles and responsibilities.

5. Apprehension with respect to anti-trust activity, and uncertainty concerning Federal regulations may continue to delay cooperative research activities and the implementation of technical programs of potential public benefit.

6. To meet competitive standards of reliability and economy in a mass-produced product, substantial time is required for the design, testing, and manufacturing of new automotive components. Under normal conditions significant innovations require three to five years for introduction into the automotive production cycle.

IV. The Role of Government

1. It is clearly established that Government has primary responsibility for research and the collection and dissemination of data relating to the effects of air pollution upon health and welfare and for the promulgation of realistic and effective national standards for air quality.

2. Vehicles meeting Federal standards for 1968, and California standards for 1970, will represent substantial progress toward control of automobile-generated air pollution, but additional controls will be required in the future.

3. The development of novel components and related automotive systems has been expedited through the use of Federal funds to support research and development in selected scientific areas.

4. The use of air pollution characteristics as essential criteria in the vehicle procurement process of Federal, state, and local governments could be a useful stimulant to the development and demonstration of low polluting vehicles.

5. Current automotive air pollution control devices are vulnerable to progressive degradation and alteration, and periodic inspection and adjustment are essential. The organizations, procedures and personnel for implementing this phase of a national program are not available.

6. State and local government agencies, with a few notable exceptions, particularly in the State of California, have not recognized the importance of the automotive air pollution problem.

7. Authority and responsibility for air pollution research and control activities have not been established at an organizational level within the Federal Government consistent with the magnitude and importance of this problem.

The Panel makes the following recommendations to the Federal Government as a Program for Progress in the control of air pollution:

RECOMMENDATION 1

The national goal for air quality should be the achievement of an atmosphere with no significant detectable adverse effect from air pollution on health, welfare, and the quality of life. 9

RECOMMENDATION 2

The Environmental Science Services Administration of the Department of Commerce should establish a research program to determine the effects of air pollution on atmospheric processes. 16

RECOMMENDATION 3

The Department of Health, Education, and Welfare should develop and promptly implement an expanded program to establish quantitative information regarding the effects of air pollution upon health and welfare of the population. 16

RECOMMENDATION 4

The Federal Government should continue to establish standards for all harmful automotive emissions, and realistic timetables for the achievement of such standards. 21

RECOMMENDATION 5

The Federal Government should immediately establish standards for the lead content in gasoline which will prevent any further increase in the total quantity of lead emitted to the atmosphere. The Department of Health, Education, and Welfare should begin an intensive study of the long-term health effects of lead in the atmosphere to determine requirements for future action. 24

RECOMMENDATION 6

The Federal Government should set standards for emissions, including smoke and odor, for gasoline and diesel powered trucks and buses. 25

RECOMMENDATION 7

The Federal Government should increase its support for mass transportation research, development, and demonstration programs related to the reduction of air pollution. 33

RECOMMENDATION 8

All Government standards concerning vehicle emissions should be developed in terms of the total mass of specific pollutants emitted under an appropriate driving cycle, rather than as the percent of pollutant in the exhaust. 36

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RECOMMENDATION 9

The creation of effective local inspection mechanisms to enforce vehicle emission standards should be encouraged by the use of Federal matching grants for training, equipment, and operation. 39

RECOMMENDATION 10

The Federal Government should develop cooperative mechanisms to accelerate the worldwide interchange of information relating to air pollution, its effects, and control. 41

RECOMMENDATION 11

The Department of Health, Education, and Welfare should establish primary operating responsibility for the air pollution control program at the highest possible organizational level. 42

RECOMMENDATION 12

The Secretary of Health, Education, and Welfare should establish a Technical Advisory Board reporting to the Secretary to assist in the development of plans, programs and research activities and to more effectively use the resources of the scientific and industrial communities. 43

RECOMMENDATION 13

A mechanism for coordination of all Federal activities relating to air pollution should be established as a continuing function at a high level in the Executive Branch. 44

RECOMMENDATION 14

The Federal Government should initiate a five-year program, in total amount of approximately 60 million dollars, to support innovative developments useful in the establishment of future emission standards, in the following areas: 45

- a. energy sources for vehicles
- b. vehicular propulsion systems
- c. emission control devices
- d. special purpose urban cars
- e. general purpose vehicles

RECOMMENDATION 15

Federal, state, and local governments should incorporate low emission performance criteria as factors in the purchase of vehicles for their requirements. 46

RECOMMENDATION 16

The National Science Foundation should review its basic research and educational programs in atmospheric physics, electrochemistry and other scientific and engineering disciplines relating to the air pollution problem and ensure that such activities are receiving adequate support. 47

INTRODUCTION

Use of the private automobile for personal transport has been one of the distinguishing hallmarks of this Nation's culture. These vehicles have been symbols of status and objects of pleasure and utility for nearly three generations of Americans. Only recently have social problems associated with their widespread use, such as air pollution, become a matter of public concern. Automotive emissions were identified as an important source of atmospheric contaminants in the early 1950's, when they were shown to be the major contributor to the chemical reactions which create atmospheric smog in the Los Angeles basin.

Public action at both state and Federal levels has resulted in recent engine modifications which lower harmful emissions from the automobile, but the call for further progress continues. The issues involved in moving forward in these areas are complex and of vital interest to the Nation.

Acting with concern for the importance and urgency of this problem, the Department of Commerce, in late 1966, initiated discussions among various Federal agencies with interests in the area. This eventually led to the formation and joint sponsorship of the Panel on Electrically Powered Vehicles which was appointed by Secretary of Commerce John T. Connor in January 1967.

The Panel's operation has been conducted in close cooperation with the Commerce Technical Advisory Board under a joint support agreement with the Departments of Defense; Health, Education, and Welfare; Housing and Urban Development; Interior; Post Office; and Transportation; the Atomic Energy Commission, and the Federal Power Commission. The following were appointed to serve as liaison to the Panel and to act as sources of information on Government activities:

Government Liaison

Department of Defense

George B. Wareham
Office of the Director of
Defense Research and
Engineering

Department of the Interior

Walter R. Hibbard, Jr.
Director, Bureau of Mines
Harry R. Johnson, Designee
Office of the Director of
Petroleum Research
Bureau of Mines

Department of Health, Education, and Welfare

Arthur C. Stern, Assistant Director
National Center for Air Pollution
Control

Department of Transportation

Paul J. Larsen, Consultant
Office of High Speed Ground
Transportation
Federal Railroad Administration
William Wolman, Chief
Traffic Systems Division
Bureau of Public Roads
Federal Highway Administration

Post Office Department

Louis Feldman, Chief
Automotive Division

Atomic Energy Commission

Melvin A. Rosen, Assistant
Director for Reactor Engineering
Division of Reactor Development
and Technology

*Department of Housing and
Urban Development*

Thomas H. Floyd, Jr., Acting
Director

Division of Demonstration
Programs and Studies

Urban Transportation Administration

Federal Power Commission

F. Stewart Brown, Chief
Bureau of Power

Executive Office of the President

William L. Hooper

Office of Science and Technology

Dr. J. Herbert Hollomon,* Assistant Secretary of Commerce for Science and Technology, and Chairman of the Commerce Technical Advisory Board, presented the following charter to the Panel at its opening session on January 6, 1967 and asked for a report within twelve months:

- Survey the current state of technology of electrically powered vehicles.
- Determine the technical and economic feasibility of developing practical electrically powered vehicles.
- Compare the performance characteristics and effects of such vehicles with other present or future types of vehicles, especially with respect to air pollution.
- Recommend the appropriate role for the Federal Government in research and development in this area.

Early in the course of the study, the Panel realized that a narrow focus on the electric vehicle alone would produce a report of limited usefulness. The Department of Commerce subsequently requested that the air pollution problem be studied from the viewpoint of automotive transportation in general and include an investigation of all possible alternatives to the current gasoline engine. In order to gather the technical and economic data required to recommend an appropriate role for the Federal Government with respect to air pollution resulting from automotive emissions, six subpanels were established to provide additional experts and staff for detailed studies in the following areas**:

Air Pollution

Current Automotive Systems

Energy Storage and Conversion Systems

The Automobile and the Economy

Automotive Energy Sources

Transportation System Requirements

Two basic policies were established by the Panel. First, the Panel and subpanel members, representing a diverse background of experience, participated as individuals and as experts in their professional disciplines and not as representatives of any company, industry, or special point of view. Second, the Panel has considered only nonproprietary, unclassified information as support for its findings and recommendations so that each con-

* Now President-elect of the University of Oklahoma.

** The subpanel reports will be published in a separate volume titled *The Automobile and Air Pollution: A Program for Progress—Part II*.

clusion can be supported by facts available to the public. The Panel has no reason to believe that this restriction will significantly affect the validity of this report.

The following are among the organizations which gave formal briefings or presented written material to the Panel and its subpanels:

American Motors Corporation	Ethyl Corporation
American Petroleum Institute	Ford Motor Company
Atlantic-Richfield Oil Company	General Atomic Division,
Automobile Manufacturers Association	General Dynamics Corporation
California Department of Public Health	General Motors Corporation
California Motor Vehicle Pollution Control Board	International Harvester Company
Chevron Research Company	Japan Vacuum Engineering Company
Chromalloy-American, Inc.	National Aeronautics and Space Administration
Chrysler Corporation	Norris Industries
Coordinating Research Council	Sun Oil Company
Department of Defense	Thermo-Electron Engineering Corporation
E. I. duPont de Nemours and Company	U. S. Public Health Service
Electric Fuel Propulsion, Inc.	Universal Oil Products Company
Esso Research and Engineering Company	Walker Manufacturing Company
	West Penn Power Company
	Zaromb Research Corporation

Additional less formal technical assistance was received from organizations and individuals too numerous to allow specific identification. Field visits to automobile manufacturers, petroleum companies, and other relevant organizations were made by Panel and subpanel members to meet with both executive and technical personnel. Without such assistance this study would not have been possible, and the Panel here records its appreciation.

Shortly after the inception of the study, pressures from Congress, the Executive Branch, the press, and the public suggested the need for expediting the completion of the study. Hearings on bills presented before the United States Senate by Senator Warren Magnuson and Senator Edmund Muskie, as well as several national professional conferences, increased interest in the problem. It became increasingly clear that decisions and action were being delayed in anticipation of the Panel report. An accelerated schedule was developed and on April 5, 1967, a revised agenda was announced, with a planned date of late summer for a final report. A preliminary report was made by the Panel Chairman to the Commerce Technical Advisory Board on July 9, 1967. At that time, a preliminary draft of the Panel's summary of findings and recommendations were presented and received general endorsement.

The Panel has attempted to reach conclusions and recommend action acceptable to all members. This report is submitted without any formal dissent, but all statements are not necessarily supported by all members with the same degree of conviction. By the presentation of a unanimous report the Panel emphasizes the need for urgent, effective action.

I AIR POLLUTION— THE PROBLEM AND THE RISKS

The atmospheric contamination which accompanies industrial society is a continuing insult to man and his environment. This pollution shortens life, destroys vegetation, damages property, and threatens to alter basic meteorological processes. The rapid growth in urban areas, combined with ever expanding per capita needs for technology, energy, and transportation, are increasing the peril and the cost.

Some of the effects of air pollution generated by industry, power plants, domestic heating, refuse disposal and transportation, are apparent to all. The damage to buildings and other property, and the dirt, odor, smog, and smoke associated with contamination of the atmosphere are obvious. In some cases the damage or discomfort can be traced to a specific pollutant and particular sources. To date, public action to abate pollution has relied primarily on this course. However, the more serious effects of air pollution may be less apparent. Man cannot observe the gradual and irreversible impairment of his respiratory functions as he does the accumulation of dirt on his shirt collar or the build-up of a cloak of smog over the city on a calm summer day. In addition, the complexities involved in sorting out the ill effects of individual air pollutants have generally made it difficult to attribute specific health impairment to specific pollutants. One fact is clear, however. The evidence identifying serious, and on occasion mortal, effects on man of urban living is overwhelming. Sickness and death rates from chronic respiratory disorders especially pulmonary emphysema, bronchial asthma, and chronic bronchitis are higher in urban than in rural environments.

The rate of progress to be achieved in combatting this problem will be related to the goals which we choose as ultimate targets for the quality of our environment. The Panel therefore recommends:

RECOMMENDATION 1

The National goal for air quality should be the achievement of an atmosphere with no significant detectable adverse effect from air pollution on health, welfare, and the quality of life.

The long term goal for the Nation should be no less than this. There is no doubt that this objective can be achieved by the determined application of modern science and technology.

Rising population and urbanization trends make the rapid pursuit of such a goal an urgent objective. Research necessary for the establishment of all types of adverse effects from air pollution needs to be given full public support and the increasingly stringent emission standards needed to meet this goal should be set as early as possible and enforced with diligence. A firm national commitment to such a strategy will prevent continuing investment in obsolete technology and assure a more rapid solution to the problem of contaminated air. Federal action to achieve this end should not pre-empt state and local governments with respect to adoption of standards and regulations more appropriate for local conditions.

B. THE EFFECTS OF AIR POLLUTION

1. HUMAN HEALTH

In the past, public action in the prevention of disease has usually awaited the identification of a single causative agent. This pattern of thinking and response is inappropriate to combat the health effects associated with air pollution. The situation was described clearly by the Surgeon General of the Public Health Service in 1962:

"I submit that much of the speculation and controversy about whether or not air pollution causes disease is irrelevant to the significance of air pollution as a public health hazard.

"That there is frequently a simple association between an infectious disease agent and the acute disease reaction which it provokes was once a startling revelation. And in public health it has served us well and continues to serve us well. But we have learned that it is not the master key that unlocks all the secrets of disease and health. The idea that one factor is wholly responsible for any one illness is patently too simple to provide all the answers we need to deal with the chronic diseases which are on the rise today.

"Chronic bronchitis, which in Great Britain is established as a specific disease entity, is a good example. It develops over a long period of time and can become crippling through a combination of many factors—air pollution, smoking, repeated and recurring bouts with infectious agents, occupational exposures—all affected, perhaps, by an hereditary predisposition. What then is *the* cause of chronic bronchitis? The answer is obvious. There is probably no single cause, but there is sufficient evidence that air pollution can and does contribute to its development. This is what really matters, whether we choose to consider it *the* cause, one of several causes, or simply a contributing factor."¹

The control of all air pollution sources, including automotive, should be viewed in this context. In addition to their known specific effects discussed in the next section of this report, automotive emissions in combination with effluent from other sources contribute to an unknown extent to the general problem of air pollution. A delay in action pending availability of conclusive evidence which identifies the precise damage associated with various levels of each pollutant currently contaminating the air is unreasonable. In view of the accumulated evidence on the effects of air pollution in general, all sources need to be checked as rapidly as economics and advancing technology will allow.

¹ Cited by Secretary of Health, Education, and Welfare John W. Gardner in *Air Pollution—1966, Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, U.S. Senate, U.S. Government Printing Office, 1966, p. 23.*

Although the present state of knowledge with respect to the effects of air pollution is characterized by large gaps in information, data are available which can serve as a basis for action until more definitive studies are completed.

The Federal Government has been slow in acting upon the growing problem of automotive pollution within the atmosphere and in developing effective plans and programs in the public interest. Without the early action regarding some of these problems by the State of California, even the progress to date would have been greatly delayed.

Epidemiological research on the effects of air pollution on human populations has been under way for the past decade. The emerging conclusions from these studies of the effects of community air pollution on human health were described last year by the Department of Health, Education, and Welfare in testimony before the Subcommittee on Air and Water Pollution, Committee on Public Works, U. S. Senate:

"The main thrust of the evidence is clear and conclusive—the types and levels of air pollution which are now commonplace in American communities are an important factor in the occurrence and worsening of chronic respiratory diseases and may even be a factor in producing heightened human susceptibility to upper respiratory infections, including the common cold."

". . . there still are deficiencies in scientific knowledge of the relationship between air pollution and respiratory disease. A need exists for more quantitative information—for more precise data concerning the pollutants which affect human health and in what amounts and under what conditions they produce their effects. But the qualitative evidence is conclusive. There is no doubt that air pollution is a factor which contributes to illness, disability, and death from chronic respiratory diseases."²

Cigarette smokers and those with lung and heart disorders are thought to be in greatest danger from contaminated air.

The killing and disabling potential of aggregate community air pollution from a variety of sources has been strikingly demonstrated in repeated episodes of acute pollution which have occurred both in this country and abroad. The air pollution catastrophe in London from December 5 through December 9, 1952 took an estimated 3500 to 4000 lives. The episodes in Donora, Pennsylvania in 1948, Meuse Valley, Belgium in 1930, and New York City in 1953 and 1966 are other well-known examples of the dangers and discomforts which result from adverse meteorological conditions and high community air pollution levels.

These dramatic occurrences were primarily due to non-automotive sources of pollution, but they serve as a reminder that clean air is a precious natural resource. While man's daily consumption of food and

² *Ibid.*, pp. 22, 23.

water totals approximately 7 pounds, he requires about 30 pounds of air each day to survive. The urban dwelling man experiences higher levels of sickness, disability, and death from disorders related to breathing and circulation functions. Direct experimentation to conclusively prove that these effects are a product of air pollution is impractical, but the accumulating facts associating damage to public health from contaminated air are so suggestive that unreasonable delay in the control of all sources of air pollution is unthinkable.

The following sections summarize the known facts about contaminants associated with the automobile.

a. Carbon Monoxide—The toxic effects of carbon monoxide on humans have been known and extensively studied for some time. The primary effect is based on its strong affinity for hemoglobin, with which it combines much more readily than oxygen, to form carboxyhemoglobin, reducing the capacity of the blood to transport oxygen from the lungs to the tissues of the body. Concentrations of 30 ppm carbon monoxide for more than four hours under controlled conditions will tie up approximately 5% of the body's hemoglobin, producing measurable impairment of physiologic functions, such as vision and psychomotor performance. Concentrations higher than 30 ppm carbon monoxide are frequently observed in urban traffic. There are reports which indicate that lower levels of carboxyhemoglobin can produce measurable effects on cognitive and psychomotor performance.³ These effects would be enhanced by any additional illness or exposure which decreases oxygen uptake in the lungs, or the ability of the blood and circulatory system to carry and distribute oxygen to the living cells of the body. Cigarette smokers, for example, may have carboxyhemoglobin levels as high as 8%. An added effect from atmospheric carbon monoxide levels could entail serious health risks.

b. Hydrocarbons—No direct health effect is attributable to hydrocarbons at atmospheric concentrations experienced to date. Certain hydrocarbon derivatives emitted in automobile exhaust may have carcinogenic effects on lung tissue, but the evidence is inconclusive. The primary concern with these emissions is their indirect effect through participation in the photochemical reactions which lead to the formation of smog. Plant damage, eye and respiratory tract irritation, and reduced visibility are all associated with the formation and prevalence of photochemical smog.

c. Nitrogen Oxides—Oxides of nitrogen are major participants in photochemical smog reactions. The most significant of these pollutants is nitrogen dioxide, a yellow-brown gas which significantly reduces atmospheric visibility at low concentrations. It is known to be toxic to man, and deaths and chronic respiratory disease have resulted from exposure to this gas in mines and in farm silos where it is formed in the decomposition of silage. The low concentrations which occur in the community atmosphere have not been identified as damaging to health, but investigations have

³ John H. Schulte, "Effects of Mild Carbon Monoxide Intoxication," *Archives of Environmental Health*, November 1963, Vol. 7, pp. 30-36.

not been adequate to determine the significance of this pollutant as a public health problem.

d. Oxidants — Ozone and the peroxyacyl nitrates (PAN), in addition to nitrogen dioxide, are oxidizing agents resulting from automotive exhausts which are found in the atmosphere. These substances are associated with the eye irritation, odor, and respiratory effects of photochemical smog.

e. Lead Compounds — Lead is known to be toxic to humans, but the concentrations required for this effect, either in the body, or in the environment, have occurred only in isolated cases, usually as a result of occupational hazards. Lead also has some effects which produce no overt symptoms. It interferes with the maturation and development of red blood cells, allegedly affects liver and kidney functions, and disturbs enzyme activity, but neither these nor other bodily disturbances caused by lead have been detected in the general population to date. Epidemiological studies adequate to detect these effects, should they exist, have not been carried out.

2. VEGETATION

Ozone, the peroxyacyl nitrates, and a number of organic oxidants associated with automotive emissions have been identified as the responsible agents for damage to food, forage, and ornamental crops in most of the major metropolitan areas of the United States. Cash crop losses related to air pollution are estimated to be on the order of 6 to 10 million dollars annually in California alone.

3. PROPERTY DAMAGE

A number of specific damaging effects on materials have been identified for automotive emissions. Ozone and other oxidants in photochemical smog attack many materials, including rubber, textiles, and dyes. No firm estimates on the total costs to the Nation from this damage are available.

4. WEATHER MODIFICATION

Attention has been focused for some time on the effects of rising levels of carbon dioxide in the atmosphere due to increasing rates of combustion of fossil fuels. The infra-red absorption properties of CO_2 cause outgoing radiant heat from the earth to be captured near the surface, resulting in an increase in the temperature of the atmosphere. This phenomenon is popularly known as the "greenhouse effect." Should carbon dioxide levels be allowed to rise continually at current rates, it has been suggested that the resulting temperature rise would have dire meteorological effects, resulting in melting of the polar ice caps and raising ocean levels. This theory has been opposed recently by scientists who allege that world temperatures are actually declining as a result of air pollution due to the increase in planetary albedo, or reflection, from the greater atmospheric turbidity. Other studies suggest the selective formation of raindrops and

ice crystals which are nucleated presumably by air pollutants at the inversion layer over urban areas.

The entire area of meteorological effects of air pollutants is speculative at present and only a beginning has been made in the design of meaningful research programs. The Panel has been surprised and disturbed to learn that the existing knowledge about atmospheric processes is so inadequate.

The Panel therefore recommends:

RECOMMENDATION 2

The Environmental Science Services Administration of the Department of Commerce should establish a research program to determine the effects of air pollution on atmospheric processes.

The area of research on inadvertent weather modification is a specific responsibility of the Environmental Science Services Administration. To date, very little research has been undertaken on the interrelationships between pollution in the atmosphere and the basic meteorological processes which govern weather. These effects could have extremely significant implications upon the welfare of the world's population and a start should be made as soon as possible to learn more about this potentially important aspect of air pollution. Since the problems in this area have obvious worldwide implications, an attempt should be made in such a program to construct and cooperate in international research and monitoring efforts.

C. RESEARCH ON AIR POLLUTION

While the past decade has seen a sharp rise in the level of support and scope of research on the effect of air pollution on health and welfare, it is clear that far more needs to be done. Many problems will require long and intensive study before definitive findings can be reached. The pursuit of knowledge in this area should be given the highest possible national priority.

To this end, the Panel recommends:

RECOMMENDATION 3

The Department of Health, Education, and Welfare should develop and promptly implement an expanded program to establish quantitative information regarding the effects of air pollution upon health and welfare of the population.

IV THE ROLE OF GOVERNMENT

Government responsibility, especially at the Federal level, for air pollution research and regulation is accepted. The effects on public health, the interstate, and international, nature of the problem, and the relation to government programs in other areas are all legitimate initiatives for action. The fact that Government has a major role to play in this area is unquestioned, but a number of fundamental uncertainties affect the ability of the Nation to agree upon long-term standards and strategies for air pollution control. The following sections discuss the more significant issues involved.

1. UNCERTAINTIES IN AIR POLLUTION CONTROL

a. Health Effects of Pollutants—Many of the constituents of automobile exhaust — carbon monoxide, nitrogen oxides, lead-compound aerosols— are well known industrial hazards. Toxicity standards for industrial exposure have been established, and progressive companies whose employees come into contact with these substances insist upon safety controls and medical monitoring; however, knowledge regarding the effects of moderate-to-low concentrations of these pollutants over the long term for all population groups is generally unavailable.

If chronic or cumulative effects resulting from prolonged or repeated exposure to relatively low concentrations of pollutants are important, even if only for certain segments of the population, for example, young children, pregnant women, or the aged, the control standards may have to be exceedingly stringent. Such standards might require pollution control measures beyond any now envisioned, or might necessitate serious efforts to develop essentially pollution-free vehicles for use in areas where the problem is especially severe.

b. Micrometeorology— Knowledge of small-scale atmospheric convection and diffusion, and of the processes involved, is critical in evaluating automobile emission standards and to an understanding of the biological, physical, and chemical effects of pollutants. Where pollutants are rapidly dispersed, higher emissions can be tolerated; conversely, where

local air is stagnant, so that pollutants collect, only very low emissions can be tolerated.

Certain streets, areas, and times of day are more susceptible than others to severe atmospheric pollution. Traffic control, taking pollution into account, thus may be able to reduce the incidence of intolerable concentrations. Similarly, certain building patterns, and expressway designs and locations, may lead to greater pollution—either on the expressway or in immediately adjacent areas—than others which use or enhance favorable micrometeorological processes. Since expressways, and reorganizations of streets, buildings and topographical features tend to result in expensive and semi-permanent changes to metropolitan areas, care should be taken to ensure that pollution incidence is not increased. Improper city design may inadvertently offset a considerable part of the pollution reduction gained from automobile engine modification.

Concomitantly, emission standards, notably at low levels, will be difficult to set and enforce without better understanding of the relevant micrometeorological processes.

c. Ultimate Limits for Internal Combustion Engine Pollution Control —

Understandably, ultimate emission levels for the internal combustion engine are not known. Neither are the specific technologies now known that will be needed to attain "ultimate" levels with any degree of certainty.

The "ultimate" required levels are also unknown because of the uncertainties concerning biological, aesthetic, and physical effects of pollutants, and the uncertainties involved in relating exhaust concentrations to concentrations in the air.

Also, "ultimate" limits, once attained, may prove too high for some pollutants under some conditions. Dispersion of metropolitan areas, combined with increasing demand for automotive travel, may offset much of the engineering reduction in pollutant emissions. It is possible that cumulative exposures may heighten pollutant sensitivities in certain individuals. When combined with locally unfavorable meteorology, the emission levels may simply be too high according to the pollution standards *then* in effect.

d. Reliability and Performance of Current and Projected Pollution Control Devices —

The reliability and performance of pollution control devices over time has not been demonstrated adequately. If currently approved devices, and their descendants, deteriorate significantly, progress in pollution control may be only a fraction of that now estimated.

Some form of testing or inspection, either of all cars or of meaningful samples, will be necessary to monitor deterioration of control devices with increased use. Quick, inexpensive, and reliable measuring tests and instrumentation will be essential. Current tests and devices, although better than their predecessors, are still inadequate for large-scale application. Also, to ensure effective compliance with Federal and state laws relating to motor vehicle air pollution, inspection systems and procedures, and methods of funding will be needed. Such inspection systems will require extensive development of stations with trained inspectors and complex equipment.

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To ensure adequate progress in establishing the necessary inspection and enforcement procedures the Panel recommends:

RECOMMENDATION 9

The creation of effective local inspection mechanisms to enforce vehicle emission standards should be encouraged by the use of Federal matching grants for training, equipment, and operation.

At the time of this writing, amendments to the Clean Air Act which would establish such a program are pending before Congress. The Panel specifically supports and encourages the early passage and implementation of this plan as an essential item in the Nation's attack on air pollution.

e. Public Acceptance of Unconventional Systems — Predicting public demand for any new product is difficult and perilous. The unconventional, low-polluting transportation vehicles discussed in this report, such as electric and steam cars using modern technology, have not been made available to the public, so that any conclusions about marketability must remain speculative.

It is possible that such transportation innovations may not displace demand for the current automobile but may induce a new consumer demand as people find ways to use the special advantages of the new product. Hence, research, development and demonstration of transport alternatives that involve departures from current performance and design characteristics should not be ruled out *a priori* if they are attractive by pollution reduction criteria.

f. Relations of Automotive Transportation to the Metropolitan "System" —

The detailed relations between transportation, particularly automotive transportation, and the rest of the metropolitan system are unclear. Although transportation helped to form the shape and character of American metropolitan areas until very recently, it is not clear whether transportation is still a determining force or whether it has become a dependent variable responding to other forces. The effect of improving downtown traffic flow, for example, is not clear. The net increase in average speeds, which leads to a reduction in air pollution, could be offset by a corresponding increase in traffic volume attracted by the lessened congestion, and by a decrease in the use of public transportation.

Metropolitan areas are both complex and diverse, and the relevance of current conditions as constraints for future development is not obvious. A demand for optimal performance in the current environment of pollution control technology that will operate some decades hence is unrealistic. But, because of the long times required for effective development, it is

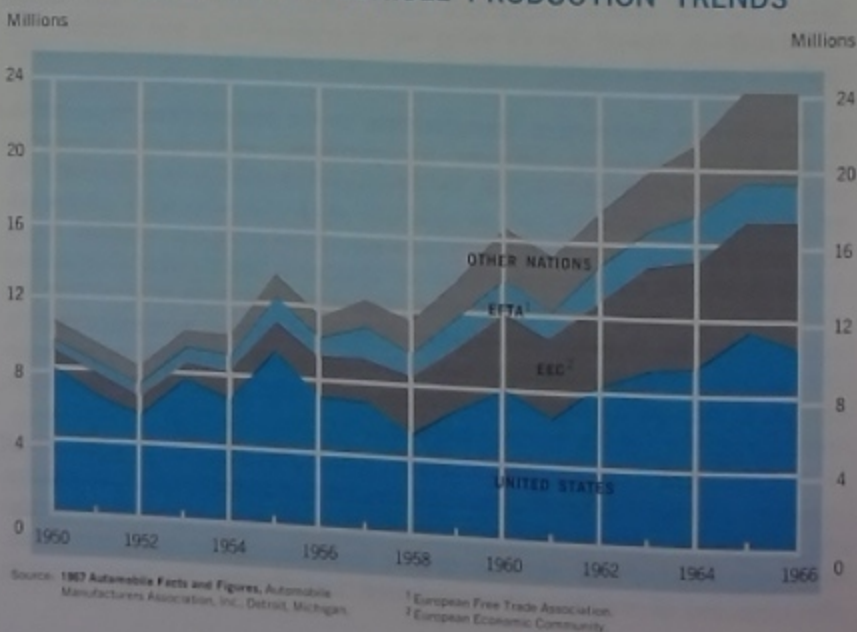
not feasible to postpone selection of development projects until the feasibility of commercial usage is unquestioned. The logical, practical course is one of sequential decision-making: choosing alternative paths to be pursued in parallel, early testing of new developments, and preservation of as many degrees of freedom as possible until specific decisions must be made.

Because of the uncertainties discussed above, there is not and cannot be one "solution" to motor vehicle air pollution. To deal effectively with the uncertainties, several simultaneous supplementary and complementary approaches need to be followed. Rather than wait for evidence that may never adequately be collected, policies should be developed to gain from learning and experience, and funds should be allocated among alternative paths that balance the costs of action against the risks and costs of inaction.

2. THE WORLD AIR POLLUTION PROBLEM

Air pollution does not respect political boundaries, yet there has been very little concerted international action in this area. Pollution in other industrialized countries and most major cities of the world is frequently more severe than that experienced in the United States. London, Tokyo, Madrid, and Rome, to name but a few, are all beset with growing levels of air contamination. Much of this plight is due to rising levels of industrial production and expanded use of the automobile. The following chart indicates the sharp increase in foreign motor vehicle production. The trend appears certain to continue.

FIGURE 14 WORLD MOTOR VEHICLE PRODUCTION TRENDS



The life-supporting atmosphere surrounding the earth is a thin layer of fixed quantity. All of mankind requires and shares this common resource and the problems associated with its contamination are the concern of every nation.

The peril of serious air pollution is a threat in all urban areas as man speeds towards high levels of industrialization and concentration of population in giant metropolitan areas. In many areas of the world, pollution levels have already reached the point where no one country can unilaterally assure air quality for its citizens, a situation similar to the interstate air pollution difficulties experienced in the United States. Although this aspect of the problem has not yet fired public opinion, the worldwide significance of air pollution is, at least today, probably more serious in terms of health and welfare than that of radioactive fallout from nuclear tests. The need is clear for early action and the establishment of cooperative programs should be delayed no longer.

The Panel therefore recommends the following:

RECOMMENDATION 10

The Federal Government should develop cooperative mechanisms to accelerate the worldwide interchange of information relating to air pollution, its effects, and control.

Neither ideology nor the requisites of economic competition are barriers to progress in this area. National and international efforts to bring about clean air for man should encourage the establishment of mechanisms of the free exchange of information and technical assistance on the nature of air pollution, its sources, effects, costs, and methods of control. This Nation should be generous and active in sharing information and experience accumulated in this area. Joint international efforts relative to the identification and monitoring of weather modification effects, health hazards, and the economic impacts of air pollution would be in the interest of all mankind. Special efforts should be made to inform the rapidly developing nations of the magnitude of this problem so that adequate control measures can be considered before pollution levels become serious or costly investment is made in obsolete technology. This country can also benefit from the activities of other nations now concerned with their own air quality problems.

3. FEDERAL ORGANIZATION FOR AIR POLLUTION CONTROL

a. Authority and Structure in the Department of Health, Education, and Welfare—General authority for Federal programs concerning the control of air pollution has been assigned to the Secretary of Health, Education, and Welfare. This role is the clearly stated intent of Congress in the Clean

Air Act and was recently emphasized by the President in his Memorandum of April 21, 1967 to the Executive Branch on air pollution.

Primary responsibility within the Department with respect to air pollution problems has been delegated to the National Center for Air Pollution Control. This is a new organization, established on January 1, 1967, within the Bureau of Disease Prevention and Environmental Control. The Bureau is one of seven major organizational units within the Public Health Service reporting to the Surgeon General. The Surgeon General as well as the Secretary, the Assistant Secretary for Health and Scientific Affairs, the Under Secretary, and the Deputy Under Secretary are also often involved with air pollution matters.

The air pollution problem is one of major importance to the Nation and requires a close and effective relationship with the industrial and academic community, several other departments of the Executive Branch of the Federal Government, and state, regional and local authorities. In this context, the current organization of the air pollution program within the Department of Health, Education, and Welfare does not appear appropriate for effective action. It is difficult to identify the proper individuals with adequate authority and responsibility and the primary operating activity has been established at too low a level within the Department structure.

Some of this difficulty may arise from the fact that the current operational mechanism is new and many of the key positions have only recently been filled. However, a more visible and clearly identified organization unit, established at a level concomitant with the magnitude of the problem, should be created. From the Government point of view, several layers of authority between the Secretarial and operating levels may not seem to be an important characteristic, but those in the private sector who must maintain contact and cooperation find difficulty with such a diffuse line of authority. Air pollution is a far more complex national problem, and may have a greater impact on industry and the public health and welfare than the much publicized question of auto safety which is firmly established as a primary organizational mission at a high level in the Department of Transportation. Direct operational responsibility for all air pollution activities should be placed at the highest possible level so that important decisions and actions are supported by an appropriate organizational structure.

The Panel therefore recommends:

RECOMMENDATION 11

The Department of Health, Education, and Welfare should establish primary operating responsibility for the air pollution control program at the highest possible organizational level.

b. Advice from the Private Sector — Anyone who examines the reality of Government-business relationships in an area as significant as the control

of air pollution recognizes the great importance of a continuing dialogue and interchange of information. In an economy based on rapidly advancing science and technology, this interchange becomes highly sophisticated and technical in nature. Mechanisms which bridge the communication gap among Government, universities, and industry, and serve as independent and objective sources of advice are especially valuable. The use of expert advisory groups has become a common practice in all agencies with significant technical programs. Many such committees now exist at operating levels in the Department of Health, Education, and Welfare for assistance in planning and awarding of grants and contracts.

One significant extension of this practice is the use of a broad-based technical advisory group of private citizens at the highest Departmental level. The President's Science Advisory Committee, the Defense Science Board, and the Commerce Technical Advisory Board have all been very effectively employed for many years in performing special studies and giving advice relating to scientific, technical and management matters. A similar advisory board has recently been established by the Post Office Department in view of its urgent requirement for the use of modern technology and advanced management methods.

The Panel recommends:

RECOMMENDATION 12

The Secretary of Health, Education, and Welfare should establish a Technical Advisory Board reporting to the Secretary to assist in the development of plans, programs and research activities and to more effectively use the resources of the scientific and industrial communities.

Air pollution should be a primary concern of the Advisory Board, but it is evident that such a group could be useful in many other areas. The appropriate caliber of membership of such a proposed Technical Advisory Board would enhance the general scientific and technical image of the Department, improve its relations with industry and the public, and assist in the recruitment of high quality talent.

An advisory group at this level should include private citizens with a variety of professional backgrounds drawn from the industrial, academic, medical and government communities. Although technical advice would be of particular importance, members with economic, legal, managerial, labor, and other non-technical backgrounds could make an important contribution. Experience also suggests that the competence of the Chairman, his ability to attract outstanding talent, and his immediate access to, and support from, the Secretary is of primary importance.

An HEW Technical Advisory Board could be an important forum for the integration of varying viewpoints relating to science and technology,

management, and organization and could serve as a basis for advice and action on important questions of public policy.

c. Coordination of Federal Activities Relating to Air Pollution—The primary responsibility of the Department of Health, Education, and Welfare with respect to air pollution is clear, but the issue affects the programs of many other departments and agencies. The Department of Transportation spends large sums in the construction of interstate highways for automotive vehicles. The Department of Housing and Urban Development supports research, development, and demonstration projects related to urban travel. The Department of Defense and the Post Office operate large fleets of vehicles. The Department of the Interior and the Federal Power Commission are concerned with natural resources and energy. The Department of Commerce operates the major Government atmospheric research facility. The list is far longer, but these examples illustrate the diversity and interrelationships which exist throughout the Federal program structure in the air pollution field.

To date, no meaningful attempt has been made to establish a continuing review of the entire range of Federal programs in order to compare and coordinate those activities which relate to air quality. To correct this deficiency, the Panel recommends:

RECOMMENDATION 13

A mechanism for coordination of all Federal activities relating to air pollution should be established as a continuing function at a high level in the Executive Branch.

No specific recommendation on location or composition of this function is made, but a meaningful implementation would involve the participation of key administrators in each program area which has a significant relation to air contamination. Although it is difficult for coordinating bodies of this type to directly influence agency program decisions, an attempt should be made to identify and examine all Federal programs which bear on the air pollution problem. Such a review by responsible officials on a continuing basis can provide the opportunity to formulate new approaches for the improvement of air quality, avoid duplication of effort, and expedite decisions and subsequent action.

4. FEDERAL SUPPORT OF POLLUTION CONTROL RESEARCH AND DEVELOPMENT

The widely recognized responsibility of the Federal Government to set and enforce standards for air quality has been often stated in this report. A start has been made in the direction of control of automotive pollution sources and it is clear that a continuing effort to reduce these contaminants will be required if the Nation's air, especially in urban centers, is

to meet acceptable standards. Close cooperation between the private and public sectors of the economy will be needed to achieve maximum progress by allowing standards and regulations to be set in light of the best available technology for pollution control. In view of this fact, the Federal Government must assure itself that the most advanced technology is available so that its regulatory action is both progressive and realistic. To provide this information on a continuing basis, the Panel recommends:

RECOMMENDATION 14

The Federal Government should initiate a five-year program, in total amount of approximately 60 million dollars, to support innovative developments useful in the establishment of future emission standards, in the following areas:

- a. energy sources for vehicles
- b. vehicular propulsion systems
- c. emission control devices
- d. special purpose urban cars
- e. general purpose vehicles

The recommended support level is seen as a modest investment for future air quality and amounts to approximately 13 cents per year for each vehicle currently in operation in this country.

The Government should not become involved itself in vehicle manufacture or in the design of complete vehicles for consumer use. The specific intent of this recommended program is to provide support for that research and development which is necessary to demonstrate potentially attractive alternatives for automobile pollution control. By such a procedure effective standards and regulations can be put into effect more rapidly, and both the public and industry will have an opportunity to examine new innovative approaches to vehicle design at an earlier date.

Such a program would allow the Nation to employ a wider spectrum of its total scientific and engineering talent for progress in this important area. A previous Panel of the Commerce Technical Advisory Board⁹ pointed out after extensive study of the innovative process that many new and useful ideas involving advanced technology arise outside the established structure of the large industrial complex with which they are associated, and they usually find great difficulty and delay in reaching the marketplace. The recommended program would provide an alternative

⁹ *Technological Innovation: Its Environment and Management, report of the Panel on Invention and Innovation, U.S. Department of Commerce, January 1967.*

source of support for innovative concepts which arise in this context. This early support for creative and promising pollution control techniques could shorten the delay between invention and use. The critical nature of the problem demands that abatement technology be advanced through the development, demonstration, and test phases as quickly as possible.

5. GOVERNMENT PROCUREMENT POLICY

The use of Government purchasing power is becoming widely recognized as a tool for fostering the advance of technology and expediting its introduction in areas of public interest. One method of employing this mechanism involves the use of explicit specifications in the procurement process. The introduction of new design specifications, management methods, and quality control procedures by the military and NASA has expedited the industrial development of design and manufacturing methods which now have applications in the civilian sector of our economy.

This technique can be useful where the desired technology is known, tested, and ready for incorporation into an automotive vehicle. For example, the Federal Government specified safety equipment on new vehicles purchased for Government use by the General Services Administration prior to general public use.

In pollution control, however, an urgent need exists for the rapid development, introduction, and evaluation of new and improved designs and devices. The Government should make every effort to encourage industry to perform research in this field and should provide incentives for the testing and demonstration of innovative ideas. The use of low pollution performance criteria rather than detailed product specification in the vehicle procurement process would provide strong incentives for trial concepts by allowing purchasing authorities to use improved pollution characteristics, even at some additional cost, as criteria for evaluating bid proposals.

This procedure could be employed by government at Federal, state, and local levels. Rapid mileage accumulation and quick turnover of automobiles participating in such an activity could offer valuable assistance in early evaluation of the effectiveness of new pollution control systems. Cooperative programs combining the purchasing powers of various government agencies within and among these levels in various areas throughout the country would be especially effective.

The Panel therefore recommends:

RECOMMENDATION 15

Federal, state, and local governments should incorporate low emission performance criteria as factors in the purchase of vehicles for their requirements.

Since a minimum of existing vehicles general use as soon purchases 80,000 million dollars. U requirements would demonstration of potential market

6. BASIC RESE

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Since a minimum of ten years is required to replace the entire stock of existing vehicles, more effective control systems should be brought into general use as soon as possible. The Federal Government alone currently purchases 80,000 automotive vehicles per year at a total cost of 175 million dollars. Use of pollution performance criteria in filling these requirements would provide an opportunity for the rapid introduction and demonstration of innovative control methods by offering this substantial potential market on a preferential basis to more progressive manufacturers.

6. BASIC RESEARCH AND AIR POLLUTION

Continuing progress in the understanding and control of air pollution will become increasingly dependent upon the advance of basic research and the training of qualified technical personnel in a number of scientific disciplines. Since World War II, the Federal Government has assumed a major responsibility in the support of basic research in general and for the advancement of technical competence in fields important to the Nation's interest. Government support of research and development projects on fuel cells and batteries, for example, has proven to be an important factor in the advance of these technologies. Many of the recent applications of electrochemical power supplies to vehicular propulsion would not be possible if Federal support had not been previously available for development and demonstration.

Many of the scientific disciplines which are relevant to the nature of air pollution, its involvement with atmospheric phenomena, its effects, and its control have been receiving support from the Federal Government. Research in atmospheric physics, electrochemistry, and other related scientific and engineering disciplines is fundamental for future solutions to the many complex problems which must be solved.

The problem of air pollution is certain to continue to plague this Nation and the world at an expanding rate. To ensure the proper level of basic research in this field, the National Science Foundation should examine current activities and take steps to correct any deficiencies.

RECOMMENDATION 16

The National Science Foundation should review its basic research and educational programs in atmospheric physics, electrochemistry and other scientific and engineering disciplines relating to the air pollution problem and ensure that such activities are receiving adequate support.

As an example, the recent emphasis given to the possibility of using electrical means for private transport has highlighted the inadequacy of our fundamental understanding of electrochemical systems. There is no doubt that these processes will be increasingly involved in supplying a

variety of personal and public energy needs, but the levels of basic research are currently inadequate to rapidly advance this field and to attract more than a few qualified researchers.

V CONCLUSION

The uncertainty and risk which pervade the establishment of public policy in the area of air pollution control require that a number of simultaneous steps be taken to protect the public health and welfare.

The sixteen recommendations presented in this report constitute a minimum set of action steps which should be included in the national program for combatting this threat. Compared to total national outlays in the field of transportation, the cost of these steps is small, and should be considered a minimum investment in the quality of life for the future.

The
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