ADVANCED AUTOMOTIVE PROPULSION SYSTEMS:
INCENTIVE FINANCING

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U.S. DEPARTMENT OF ENERGY

Assistant Secretary for Conservation
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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

At present, close to half of the oil used in the United States is imported. The largest single demand for oil comes from the transportation sector, where internal combustion highway vehicles require about 7.5 million barrels per day. In order to reduce this high demand, Congress has authorized a program of research and development dealing with advanced automotive propulsion systems (AAPS). In compliance with the "Automotive Propulsion Research and Development Act of 1978," Title III of Public Law 95-238, the Department of Energy (DOE) is undertaking expanded research to develop and demonstrate advanced propulsion systems by 1983. Section 310 (b) of the Act requires the Secretary of Energy to determine whether and under what conditions AAPS development could be aided by a Federal loan guarantee program, and to report his findings and recommendations to the Congress within one year from the date of enactment. In making this determination, a survey and study were made to:

- Analyze the use of various forms of Federal financial incentives, including loan guarantees, in relationship to the development stages of a new technology. (Section 2)
- Elicit comments and opinions on the AAPS state-of-the-art and the perceived usefulness of loan guarantees from members of the automotive industry, research organizations, and the financial community. (Section 3)
- Formulate conclusions and recommendations for transmittal to Congress on the advisability of using loan guarantees to aid AAPS development. (Section 4 and Section 5)

In general, the forms of Federal financial incentives which are appropriate to aid new technology development depend on the stage of development of the technology and the capital requirements of the industry which will utilize that technology. The AAPS's are in early engineering development, where Federal grants and contracts are currently in effect. Cost sharing agreements and tax incentives may be appropriate depending on the specific circumstances.

A number of conclusions have been derived. From a technical development standpoint, it is apparent that AAPS's offer the potential of improved fuel economy,

multifuel capability, and reduced exhaust emission. Some problems exist, but these are not insurmountable and efforts to find acceptable solutions are continuing. The major automotive producers probably would not need or use loan guarantees to develop AAPS's. However, the component manufacturers may be interested in loan guarantees to satisfy the requirements of the industry. The financial community supports financial incentive programs for the automobile industry if they provide adequate protection and safeguards of investments.

Based on these conclusions and in view of the current state of technological development, which is already supported by Federal grants and contracts, and the probability of only starting limited production late in the next decade, it is recommended that consideration of legislation for authorizing Federal loan guarantees in connection with advanced automotive propulsion systems be deferred at this time.

While loan guarantees would not be an effective incentive during the present phase of AAPS development, DOE should evaluate the need for financial incentives, including loan guarantees, periodically.

SECTION I
INTRODUCTION

SECTION I INTRODUCTION

1.1 Overview

The growing disparity between energy supply and demand in the United States has caused increased concern and positive action by Government policymakers in recent years. Over time, economic growth and increases in population have added large increments to an already large base of domestic energy consumption. Oil and natural gas are receiving particular attention, since petroleum-based fuel supplies are in a state of flux.

At present, close to half of the oil used in the United States is imported. In the near term, energy demand in the Nation will continue to require increased oil imports until such time as domestic energy conservation programs and alternative sources of energy are developed. In the long range, worldwide demand for oil may exceed available resources.

Energy consumption in the United States is generally categorized into three broad sectors: (1) buildings and community systems, (2) industry, and (3) transportation. While energy supplies in the first two sectors may be partially derived from coal, atomic power, and other nonpetroleum sources, almost all the fuel used in transportation is derived from petroleum. This amounts to about half of the petroleum demand in the U.S. Energy-related legislation in recent years has therefore placed a strong emphasis on conservation in the transportation sector, with special emphasis on highway vehicles, which currently consume 7.5 million barrels of oil per day.^{1/} Several laws passed by recent Congresses contain provisions to curb energy consumption by highway vehicles. Among the laws passed, the following address aspects other than heat engine propulsion systems.

- Public Law 93-275, "The Federal Energy Administration Act of 1974," establishes programs to educate motorists in energy conservation techniques
- Public Law 93-319, "Energy Supply and Environmental Coordination Act of 1974," mandates studies of fuel economy improvement standards in new motor vehicles

^{1/}"Energy Systems Acquisition Project Plan, "Advanced Automotive Heat Engine Systems Development Project," Transportation Energy Conservation Division, Department of Energy, December 1, 1978, page 1-1.

- Public Law 94-163, "The Energy Policy and Conservation Act," promotes van pooling and car pooling, and permits the establishment of a program to increase transportation expertise at the State level
- Public Law 94-413, "The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976," promotes the integration of electric and hybrid vehicles into the Nation's transportation fleet
- Public Law 95-619, "The National Energy Conservation and Policy Act," requires fuel economy labeling for automobiles.

1.2 Automotive Propulsion Research and Development Legislation

Continuing the effort to improve the national energy posture, the Congress enacted Public Law 95-238, "The Department of Energy Act of 1978--Civilian Applications." Title III of the law deals with automotive propulsion research and development. Referred to as the "Automotive Propulsion Research and Development Act of 1978," this title expresses the findings of the Congress that:

- Existing automotive propulsion systems fall short of meeting the long-term goals of the Nation with respect to environmental protection and energy conservation.
- With sufficient research and development efforts, advanced alternatives to existing automotive propulsion systems could meet these long-term goals.
- Insufficient resources are being devoted to this effort.
- An expanded research and development effort could complement and stimulate corresponding efforts by the private sector, and would encourage automobile manufacturers to consider incorporating such advanced technology into automobiles and automotive components.

1.3 The AAPS Program

Based on such findings, the Congress has directed the Secretary of Energy to establish a program to ensure the development of advanced automotive propulsion systems (AAPS) within 5 years, or as soon as practicable. Current Government costs^{2/} are estimated to be:

^{2/} Ibid., page 2-1.

- \$125 Million for the Gas Turbine Project
- \$100 Million for the Stirling Engine Project.

In carrying out those responsibilities, the Secretary of Energy is authorized and directed to make contracts and grants with Federal agencies, laboratories, universities, other organizations both public and private, or individuals, for research and development leading to advanced automotive propulsion systems that are likely to help meet the Nation's long-term goals. The objectives are to:

- Help provide the necessary system technology to assist industry in the decision process on mass production by 1983
- Reduce petroleum requirements through efficient propulsion systems which may also use alternative non-petroleum-based fuels
- Meet the most stringent automotive emission standards as established in the Clean Air Act (42 U.S.C. 1857 et seq.).

While the Congress has approved and, indeed, has directed the use of Federal contracts and grants as incentives for research and development associated with advanced automotive propulsion systems, it has directed that a study be made of Federal guarantees of financial obligations. Section 310 (b) of the Automotive Propulsion Research and Development Act requires the Secretary of Energy to conduct a survey of developers and lending institutions and to make a study to determine whether, and under what conditions, research, development, demonstration, and commercial availability of advanced automotive propulsion system technology may be aided by the guarantee of financial obligations by the Federal Government. Section 310 (b) further requires the Secretary to submit a report of the results of the survey and study within one year from the date of enactment.

1.4 The AAPS Survey and Study

The purpose of this survey and study was to: review the available literature; contact developers, lending institutions, and other interested parties to

determine their perceived need for Federal guarantees of financial obligations for AAPS research, development, demonstrations, and commercial availability; analyze the results; formulate conclusions; and make recommendations. A secondary purpose of the effort was to establish a dialogue with members of the automotive industry and the financial community which would facilitate development and rapid implementation of AAPS energy conservation programs. This report presents the results of the survey and study.

A background review of the complexities of advanced automotive propulsion systems and of financial incentives is presented in Section 2 of this report. Section 3 sets forth the methodology employed in developing the material for the report and reviews the information gathered through literature review, and individual and group discussions. The conclusions drawn from this information are summarized in Section 4, leading to the recommendations made in Section 5. Additionally, comprehensive appendices are provided for ready reference and ease in understanding the report.

SECTION 2
BACKGROUND

SECTION 2 BACKGROUND

2.1 General

This section presents background information associated with this survey and study of advanced automotive propulsion systems (AAPS). Three aspects of AAPS are addressed: technical, industrial, and Federal financial incentives. A brief technical discussion of AAPS is presented, followed by an overview of the automotive industry. Financing and the role of Federal financial incentives in energy conservation projects are then addressed.

2.2 Advanced Automotive Propulsion Systems

Since 1971, various Federal agencies have evaluated alternatives to the conventional internal combustion engine (ICE). From these evaluations, the heat engine systems which met all long range conservation, environmental and standards were the Brayton (gas turbine) and Stirling engines. While there are other advanced automotive heat engines such as the stratified-charge Otto, advanced diesel, and Rankine engines, which are being pursued by the automotive industry, they will not meet all long range national objectives of reducing petroleum consumption by 30 percent, by 1985, and elimination of petroleum as their prime energy source by 2000. Electric and hybrid propulsion systems development is under the aegis of another Department of Energy (DOE) program. This report focuses on financial incentives, particularly loan guarantees, in the development of the Brayton and Stirling engines. These advanced heat engine power systems are aimed for commercialization during the 1985-2000 interval.

DOE programs are now focused on engineering development of gas turbine and Stirling engines to provide good fuel efficiency, multifuel capability, low emissions, and competitive cost. The gas turbine and Stirling engines are broadly defined and discussed in the following paragraphs.

2.2.1 Gas Turbine Engine

The Brayton engine, known as the gas turbine engine, is an ICE that produces power by the expansion of hot combustion gases passing through a turbine. A portion of the output of the turbine is used to compress the inlet air. In

configurations under development for automotive propulsion applications, the exhaust gases from the turbine pass through a regenerator which acts to preheat incoming air. (For more detail see Sawyer's Gas Turbine Engineering Handbook, Volumes I, II, and III, Business Journals Incorporated, 1972.)

To be a viable contender for future automotive markets, the advanced gas turbine engine will need to be mechanically simple, lightweight, and economical. It will have to offer a significant economic advantage over future generation internal combustion engines.

2.2.2 Stirling Engine

A Stirling engine is a closed cycle machine which converts thermal energy to mechanical work by alternately compressing and expanding a confined working fluid with heat rejection during compression and heat addition during expansion. The cyclic movement of the working fluid in the engine is accomplished by volume changes in the working volume rather than intermittently closed valves. The cycle includes thermal regeneration, which is accomplished with a storage heat exchanger that removes heat from the working fluid after expansion and returns heat to the working fluid after compression. (For more detail, see Automotive Technology Status and Projections, Volumes I and II, Jet Propulsion Laboratory Publication, 78-71.)

The need to conserve energy has heightened the interest in the Stirling engine because of the engine's high thermodynamic efficiency. Stirling engine technology has been available for many years but has been undeveloped. However, efforts are underway to refine and improve the Stirling engine as a power source for several applications, including automotive. These efforts have demonstrated the potential of the Stirling engine as a highly efficient candidate for the future. The recent interest in reducing petroleum use has generated several new research programs on the Stirling engine, both analytical and experimental.

2.3 Automotive Industry

Currently, much of the research and development of AAPS's involves the established automotive industry. Many of the major developmental contracts are

given to the industry; the rationale being that the industry will eventually commercialize the technology. For the purposes of this report the industry has been divided into three segments: vehicle manufacturers, component manufacturers, and researchers and developers.

2.3.1 Vehicle Manufacturers

The automotive industry in the United States consists of the four major car producers--Chrysler, Ford, General Motors, and, to a lesser extent, American Motors. Additionally, there are several other smaller, more specialized firms such as Checker Marathon and certain custom vehicle manufacturers. Most of the research effort on advanced propulsion systems is being conducted by the three largest producers. Chrysler and General Motors have research underway in the development of a gas turbine engine, while Ford is concentrating on its own PROCO design, which is a programmable ICE. Ford has also been developing Stirling engines, but recently indicated that it would cease further efforts on this program. Ford does continue to support development of components for Stirling engines, specifically in the area of ceramic regenerators.

2.3.2 Component Manufacturers

The component manufacturers include those firms producing items such as combustors, heat exchangers, transmissions, and other components. Manufacturers of materials for these components are also included under this category. In fact, materials manufacturers may play the leading role in early development of acceptable systems. New ceramic materials for gas turbine engines and specialty stainless steels for Stirling engines are needed. These components must be capable of meeting extremely high temperatures during engine operations and also meet stringent machining requirements.

2.3.3 Researchers and Developers

Most research and development efforts in AAPS's are conducted by automobile manufacturers, component manufacturers, Federal laboratories, universities, private laboratories, and individual researchers. Federal laboratories

are mentioned here solely to recognize their input to automotive propulsion systems and not as entities which might be recipients of financial assistance.

2.4 Federal Financial Incentives

It is usually costly and risky to implement plans for product improvement, process improvement, and new product development. The information presented here is intended to facilitate a greater understanding of Federal financial incentives and how they apply to AAPS projects.

NASA's Jet Propulsion Laboratory (JPL) has derived some cost comparisons for various types of automotive engines, comparing the variable costs, selling prices, price differentials and price increase factors. The report indicates that the estimated price difference between the Brayton (gas turbine) engine and the conventional gasoline engine is \$500-600 (1977 dollars) for a full-sized car. The Stirling engine is estimated to be \$800 higher in the 100-150 hp size range. Even though engine costs only amount to about 10 percent of the cost of a full-sized car, investments in research and development are needed to make these AAPS's more cost competitive to accelerate their commercialization. (For further detail, see Energy Systems Acquisition Project Plan, Transportation Energy Conservation Division, Department of Energy, December 1, 1978.)

The Federal Government can be a major source of research and development funds. In the interest of national economic growth and pressing national needs, the Government often funds private sector industrial research and development efforts. Other financial incentives have been applied when it was in the national interest to motivate industry to develop new or improved products. Research and development efforts often involve risks greater than investors are willing to assume, since such efforts seldom produce revenue. The Federal Government has often assumed or defrayed some portion of extraordinary risks, while depending on industry and private capital to assume the ordinary investment risks and to take responsibility for the design and operation of the projects.

There are procedures by which the Government can share risks. Risk-sharing should incorporate basic objectives which include:

- A program to provide sufficient incentive to attract private capital

- A risk-sharing program that is simple to administer, under which private investors and the Government know exactly what they can expect and what risks they will bear
- A program seen by Congress and the public as fair and equitable. The Government should not assume all the risks while all the profit goes to industry (ideally, all the parties share both risks and rewards).
- Provisions for the withdrawal of Government participation when the risks have been reduced to manageable levels through operating experience.

The Government can provide risk participation on either a project-by-project basis or a more general program basis. Provisions and conditions are contingent on the types of risks involved. The perceived risks could apply to future market prices, technological uncertainties, cost of production facilities, or uncertainties regarding future Government regulatory actions.

A wide range of Federal programs has been developed that affects both the amount of capital formation and the allocation of capital among potential projects. These include:

• Tax incentive programs	• Purchase agreements
• Contracts	• Direct loans
• Cost sharing	• Loan guarantees
• Grants	• Price supports

In general, the appropriate form of financial incentive for commercialization of a new energy technology is related to: (1) the technological, economic, and market feasibility of the energy project; (2) the length of time required for commercialization; and (3) the credit standing and managerial, financial and technical needs and expertise of the developing industry or firm.

Figure 2.1 shows five chronological phases leading to the commercialization of a new technology: Research and Development, Prototype Development, Demonstration, Limited Production, and Full Production. The types of incentives are listed in the left column. Their applicability to each program phase is indicated by a solid horizontal line, a broken line, or a blank space. A solid

FINANCIAL INCENTIVES FOR DEVELOPMENT/ COMMERCIALIZATION STAGES

Figure 2.1

TYPE OF INCENTIVE	RESEARCH & DEVELOPMENT	PROTOTYPE	DEMONSTRATION	LIMITED PRODUCTION	FULL PRODUCTION
Tax Incentives					
Contracts					
Cost Sharing					
Grants					
Purchase Agreements					
Direct Loans					
Loan Guarantees					
Price Supports					

Key:

Normal Method of financial assistance

Alternate method of assistance

line indicates that a specific incentive may be applicable in a specific phase. A broken line indicates that an incentive may be applicable under certain alternate circumstances. A blank space shows that the incentive may not be appropriate for that phase.

Tax incentives can serve to increase and sustain private sector investment in technological developments. These incentives may be particularly useful to firms with fixed or limited budgets for R&D and/or new product development. A reduction in taxes essentially increases the capital available for a firm to expand, intensify, or continue desired programs. Tax incentives may be appropriate throughout the entire commercialization process when substantial amounts of capital are invested in fixed assets. However, firms must have sufficient revenues and profits to use tax incentives effectively, and this factor can limit the value of certain tax incentives to less profitable firms and to specialized ventures. Also, the costs and benefits of tax incentives tend to become permanent once instituted.

The Federal Government's share of risk and cost outlay is usually greater in the early phases of development, when the end product is far from commercialization and the risks are higher. In the early phases of technological development, through the Limited Production phase, contracts may be useful forms of Federal financial assistance. As the project progresses, the Federal risk could be reduced to a point where other forms of assistance may be more appropriate. Research and development contracts may in some cases continue to be appropriate to sustain efforts during the Full Production phase.

Federal cost-sharing incentives may be used to stimulate technological development. Forms of cost-sharing may be applicable from Research and Development to the beginning of a technology's Full Production phase, or earlier, whenever the technological program becomes self sustaining. The potential benefits of cost sharing are: (1) there should be an acceleration and cross fertilization of public and private research and development; (2) the cost sharing increases capital availability to the private sector; and (3) the Federal Government has reasonable assurance of achieving its goals. The potential problems of cost sharing are: (1) it could distort the normal flow of capital in private sector financial markets; (2) Federal Government participation could be jeopardized by failure of the project; (3) the private financial markets would not gain significant experience in financing the new technology; and (4) the requirements for Federal and private sector coordination would involve substantial administrative expenses.

Grants, which provide front-end capital and solve the problems of capital availability and exposure, may be appropriate from the start of the Research and Development phase through the end of the Demonstration phase. Grants can, in some cases, also be useful forms of Federal assistance during the Limited Production phase. However, grants could distort the normal flow of capital in private sector financial markets, and if loosely constructed and monitored, may not achieve Federal goals.

Purchase agreements, while sometimes useful during the Prototype and Demonstration phases, may be especially appropriate during the Limited and Full Production phases. They may assist firms raising capital and they should permit a satisfactory return on investment. On the negative side, purchase agreements could generate Federal administrative difficulties and expenses. Also, they would not reduce capital exposure in the case of production interruption or failure.

Direct loans, with possible interest subsidies, may serve as incentives from the Prototype phase through the Limited Production phase. The primary problems with direct loans are the private sector financial institutions do not get acquainted with the needs and potential of the emerging technology, and the Federal Government bears all of the risks and incurs substantial administrative costs.

Federal loan guarantees can be appropriate during Limited Production and Full Production as long as the project will generate sufficient revenue to repay the loan, both principal and interest. Loan guarantees may address the industry's capital availability and protection needs, and may provide the impetus for rapid commercialization of a feasible technology. In addition, Federal front end costs are low, and administrative costs may be low if guarantee fees cover those costs. Both industry and the Federal Government share the risk of development if private equity is required in the project. On the other hand, loan guarantees do not address the problem of profitable operations. They presuppose an effective credit screening by lenders when it is possible that lenders are lax in their credit evaluations. Moreover, if the technical and financial aspects of a proposed project are not thoroughly examined, loan guarantees may, in reality, result in the inefficient allocation of resources.

Price support incentives become applicable during the Limited Production and Full Production phases of product development. Because consumers are

reluctant to accept new technologies and/or new products, price supports can play an important role in accelerating and continuing mass production and commercialization. They provide a guaranteed rate of return, enhance profitability, and reduce the risk of financing. On the other hand, price supports could distort normal flow of capital in private sector financial markets, may entail substantial Federal costs and continuing administrative requirements, and ignore problems of capital exposure.

SECTION 3
DATA COLLECTION AND DISCUSSIONS

SECTION 3 DATA COLLECTION AND DISCUSSIONS

3.1 Methodology

In satisfying the requirements of Section 310(b) of the Automotive Propulsion Research and Development Act of 1978, the survey and study conducted included the following steps:

- Literature review
- Identification of potential participating organizations within the automotive industry and the financial community
- Identification of issues relating to Federal guarantees of financial obligations for AAPS research and development
- Data collection through individual and group discussions with members of private sector organizations, officials of DOE, and other Federal agencies
- Data analysis and formulation of conclusions
- Recommendations.

The methodology employed in preparing this report is graphically depicted in Figure 3.1.

3.2 Literature Review

One of the early steps in the collection of data was to examine literature which would impact on an AAPS Federal guarantee program, if one were authorized (see Appendix A). The literature examined included technical information and information concerning existing Federal financial incentives.

The technical information addressed three aspects of advanced automotive propulsion: (1) the overall program for advanced automotive propulsion systems; (2) the state-of-the-art; and (3) the goals of the Federal government and the automotive industry in terms of demonstration and commercialization of gas turbine and Stirling engines. The financial literature provided insight into high risk technology

METHODOLOGY

Figure 3.1

financing, as well as budgeting processes for the automotive industry. Literature describing existing Federal loan guarantee programs was reviewed (see Appendix B).

3.3 Identification of Potential Study Participants

Many companies are examining alternatives to today's ICE. However, only a few are working toward commercial production of the gas turbine and Stirling engines, the most promising of advanced automotive propulsion systems.

With the assistance of several sources such as trade associations, university research and development programs, and referrals from several other agencies, a comprehensive listing of organizations potentially interested in AAPS was compiled. This list was then combined with a review of all entities under the appropriate Standard Industrial Classification listing to produce a composite listing of 1172 industrial organizations or individuals possibly interested in the research and development of advanced automotive propulsion systems.

Similarly, 983 potential financial participants were identified. This number included commercial banks, investment bankers, securities dealers and brokers, and financial packaging houses. Many of those identified had exposure to Federal loan guarantee programs, and many were familiar with transportation energy related programs.

In addition, a list of individuals and institutions such as universities and research organizations was compiled. This group consisted of 282 contacts, and when combined with the industry and financial groups, brought the total number of identified organizations or individuals to 2,437.

3.4 Identification of Issues

To identify issues which would be germane to group discussions, the identified organizations and individuals were contacted and invited to propose topics. Eighty-one replies were received from organizations and individuals considered to be leaders in their respective fields and whose individual opinions reflect those of the automotive industry and financial community (see Appendix C). Of the 81 respondents, 61 expressed a desire and intent to participate in group discussion sessions. The respondents who chose not to attend the group discussion

sessions were mainly representatives of the financial community. These individuals provided information through individual discussions, and their comments were considered in this report.

During the discussions, responses coincided with organizational interests. The specific issues identified were:

- Industry issues
 - Stage of development
 - Type of financial incentive associated with stage of development
 - Fuel economy
 - Identification of early production companies
 - Major development bottlenecks
 - Role of component manufacturers in development activities
- Financial issues
 - Extent of financial community participation
 - Full faith and credit
 - Payment upon default
 - Interest rates for guaranteed loans
 - Repayment problems
 - User charges
 - Provisions for cost overruns/escalation
 - Project financing versus corporate financing.

On the basis of the issues identified, a preliminary program outline was formulated and submitted to the 61 parties who had expressed intent to participate in group discussions (identified by an asterisk in Appendix C). New York, Chicago, and Los Angeles were selected as sites for group discussion sessions after direct contact was made with each potential attendee to determine mutually acceptable geographic locations. (The Los Angeles session was subsequently cancelled because of a general lack of interest.)

Finally, after all planning and arrangements had been completed, a firm list of issues along with the times and places of the discussions was forwarded to each of the 61 respondents.

3.5 Individual and Group Discussions

The following information was derived from individual and group discussions with those organizations and individuals listed in Appendices C and D. While all the thoughts expressed and comments made contributed to the study objectives, the conversations have been condensed to the essential points on which there was a consensus and to the opinions expressed which were considered to be particularly noteworthy. The salient points brought out during individual and group discussions are categorized into two parts: automotive and component manufacturers, and financial institutions.

Comments and opinions from representatives of the automotive industry are briefly summarized in the following statements.

- While there is much interest in the development of advanced propulsion systems, there is only a relatively small group that can make a significant impact on the needs of the Nation.
- Component manufacturers are relatively few, and are normally aligned with one of the major automotive producers who do not want to develop specialized and expensive "in-house" capabilities for component manufacturing.
- There is a need to develop ceramic components capable of withstanding extremely high temperatures in gas turbine engines.
- While high quality ceramic samples can be produced under controlled conditions, large production runs result in a great variance in properties.
- There is a need to develop suitable replacement materials for the high-grade stainless steel now required for Stirling engines. This is important in reducing production costs.
- Limited production of automobiles with advanced propulsion systems is possible in the mid 1980's, but full production is not expected earlier than the 1990's without Federal incentives.

- Realistic cost projections for components are difficult due to lack of experience with large-scale production of new component materials.
- Total costs of AAPS development from the conception to full production is estimated at \$2 billion, of which about one-fourth is associated with component design and production capability.
- The market outlook of the AAPS industry is one of caution in light of the market failure of the turbo-charged engine. Industry will initially proceed with market analyses, limited production, and development of limited maintenance and servicing infrastructure requirements. Industry will only tool up for mass production if there is reasonable assurance that a market for AAPS exists.
- One of the three major manufacturers felt there could be a very definite side benefit in having an authorized guarantee program. It could help sustain momentum during the commercialization phase of the AAPS program.
- A loan guarantee program would benefit component manufacturers by supporting increased production capacity once acceptable products are developed for use in AAPS. This, in turn, would help accelerate AAPS commercialization.
- The AAPS industry is in the development stage and many members feel that grants, contracts, and tax incentives are appropriate at this time. In addition, some industry representatives believe that loan guarantees would be suitable as the state-of-the-art improves and production nears reality.
- To attract the automotive industry, any loan guarantee program must assure minimal bureaucratic red tape and unnecessary paperwork.

Inputs from representatives of the financial community are summarized in the following statements.

- Introduction of a loan guarantee program should take place only when there is a promise of sufficient revenue generation to provide a means for repayment of the loan.
- In general, the form of financial incentives should dovetail with the phase of development of any given project.

If a loan guarantee program were proposed:

- The guarantee should be based on the full faith and credit of the United States.
- Borrowers and lenders should set the rates of interest subject to approval of the Secretary of Energy.
- It would be desirable to stipulate specific time periods in which payment upon default will be made, and stipulate that funds will be available for such payments.

If a loan guarantee program were implemented:

- The borrower and lender should be allowed to work toward rectifying problems which may otherwise lead to default.
- Other provisions should be included to cover such aspects as user charges, withdrawal of guarantees, and cost overruns/escalations.

SECTION 4
CONCLUSIONS

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SECTION 4 CONCLUSIONS

4.1 Introduction

The conclusions presented in this section are derived from information collected during the survey and study. These conclusions are based on analyses of available literature and on individual and group discussions with representatives of the automotive industry and the financial community.

4.2 Basic Issues

The basic issues addressed in this survey and study are whether and under what conditions Federal loan guarantees would help stimulate AAPS development. In compliance with Title III of Public Law 95-238, the Department of Energy is now undertaking expanded research to develop and demonstrate advanced automotive propulsion systems by 1983. Engineering development is focused on two types of advanced systems: the Brayton (gas turbine) and Stirling engines. Conclusions drawn, therefore, first focus on the state-of-the-art and outlook for commercialization of these AAPS's. Follow-on conclusions then address the perceived applicability of loan guarantees to accelerate commercialization.

4.3 Technical Development Conclusions

It is concluded that advanced automotive propulsion systems offer the potential benefits of improved fuel economy, multifuel capabilities, and reduced exhaust emissions. This is supported by technical data derived from testing and evaluation programs dealing with baseline equipment. However, regardless of the promise and optimism surrounding the gas turbine and Stirling engines, some technological difficulties exist, and must be overcome before full line production can occur. These difficulties are developmental in nature. While they may impede early full production, they are not insurmountable, and efforts to develop acceptable solutions are continuing.

The prerequisites to commercialization of gas turbine automobiles are competitive fuel economies and competitive costs (compared to conventional internal combustion engines). One barrier to achieving high fuel economy has been

the turbine's poor part load efficiency. Low cost and improved efficiency can be achieved simultaneously by utilizing ceramic materials in the hot sections of the gas turbine, since ceramics allow the turbine to operate at higher gas temperatures. With low-cost ceramics, there would not be a need for expensive, high-alloyed metals to sustain the higher temperatures. Commercialization prospects, therefore, are contingent on the development of appropriate ceramic materials and on the improved aerodynamic performance of small turbomachinery.

The Stirling engine development will utilize existing and near-term technology to achieve the project objectives. Fuel economy improvements are expected to result primarily from development of a higher temperature engine, the design and development of an experimental engine optimized for the automobile application, and parallel component development. Stirling engines exhibit the potential of utilizing alternative fuels, including alcohol and other nonpetroleum derived fuels.

Materials are also responsible for the major difficulties experienced by the Stirling engine manufacturers. Today, this engine requires a relatively large amount of high-grade stainless steel in its production. Unless lower cost, alternative materials can be developed for this engine, there are questions of cost-effectiveness and, consequently, market acceptance.

4.4 Applicability of Incentives

It is important that the types of financial incentives used to stimulate AAPS commercialization match the types of financial requirements at any given phase of project development and the capital requirements of the industry which will utilize that technology. Advanced automotive propulsion systems are now in the engineering development phase, where financial assistance could be appropriate in the form of grants, contracts, cost sharing, and tax incentives. Indeed the Congress has authorized the use of Federal contracts and grants as incentives for research and development. Figure 4.1 depicts the relationships between the development phases and the time intervals when various types of financial incentives could be most appropriate. As the project moves into the demonstration phase, which is estimated to last through 1983, appropriate types of Federal financial assistance could include grants, cost sharing agreements, tax incentives, or contracts for either the direct purchase or lease of engines and/or vehicles.

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RELATIONSHIP OF TYPE OF FINANCIAL INCENTIVE TO THE DEVELOPMENT STAGE OF ADVANCED AUTOMOTIVE PROPULSION SYSTEM

FIGURE 4.1

RELATIONSHIP OF TYPE OF FINANCIAL INCENTIVE TO THE DEVELOPMENT STAGE OF ADVANCED AUTOMOTIVE PROPULSION SYSTEM

FIGURE 4.1

COMMERCIALIZATION AND PRODUCTION PHASE

During engineering development, large automotive firms are capable of supporting research efforts with corporate funds. It is expected that these firms will have existing markets and products which can generate the necessary capital. Government assistance is not essential under these conditions. However, smaller firms may require Federal assistance to help overcome risks in the AAPS research and development phase.

Based on extensive discussions, it is concluded that the financial community would participate in a loan guarantee program to stimulate AAPS development in the demonstration and production phases if such a program provided adequate investment protection and safeguards. Participation by the financial community, however, would be contingent upon evidence that AAPS projects are at least in the tooling up stage and capable of generating sufficient revenues to cover debt service over the period of the loan.

Industry projections indicate that AAPS development and demonstration will continue until the mid-1980's, at which time only limited production will begin. Full line production will not begin before the late 1980's or early 1990's. This suggests an extended period of time before loan guarantees would be applicable based on revenue generation potential. Federal loan guarantees are most appropriate, however, where the industry needs assistance gaining access to or protecting capital and when there is reasonable assurance that sufficient revenues will be generated on a near-term basis (within two to four years) to permit a scheduled repayment of financial obligations.

The foregoing conclusions lead to the recommendations covered in Section 5.

SECTION 5
RECOMMENDATIONS

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SECTION 5 RECOMMENDATIONS

5.1 Introduction

Section 310 (b) of the Automotive Propulsion Research and Development Act (Title III, Public Law 95-238) requires that recommendations be made as to whether, and under what conditions, advanced automotive propulsion systems technology research, development, demonstration, and commercial availability could be enhanced by Federal guarantee of financial obligations. This section presents the required recommendations based on the review of literature, personal interviews, and individual and group discussions.

5.2 Recommendations

This report concludes that a loan guarantee program would not accelerate the current research and development efforts towards the commercialization of AAPS systems. It is recommended, therefore, that consideration of legislation for authorizing Federal loan guarantees in connection with AAPS research and development be deferred.

While loan guarantees would not be effective incentives during AAPS research and development, DOE should evaluate the need for financial incentives, including loan guarantees, periodically.

APPENDIX A
LITERATURE REVIEWED

APPENDIX A
LITERATURE REVIEWED

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APPENDIX B
FEDERAL LOAN GUARANTEE PROGRAMS
AND
FEDERALLY INSURED LOAN PROGRAMS

APPENDIX B

FEDERAL LOAN GUARANTEE PROGRAMS

Department of Agriculture:

- Business and industrial loans
- Emergency livestock line of credit guarantees
- Farm emergency loan program
- Farm operating loans
- Farm ownership loans
- Individual homeowners loans, loans for housing and building on potentially adequate farms
- Rural electrification loan guarantees
- Rural telephone loan guarantees
- Soil and water conservation loan and loan insurance program for individuals

Department of Commerce:

- Business development loan guarantees
- Coastal energy impact program
- Federal ship financing guarantees
- Fishing vessel obligation and guarantee program
- Trade adjustment assistance for communities
- Trade adjustment assistance for firms

Department of Defense:

- The Defense Production Act
- Foreign military credit sales

Department of Energy:

- Electric and hybrid vehicle research, development, demonstration, and production loan guarantee program
- Geothermal loan guarantee program
- Coal loan guarantee program
- Energy conservation and renewable resource obligation guarantees program

Department of Health, Education, and Welfare:

- Construction and modernization of hospitals and other medical facilities
- Construction of health professions teaching facilities

Department of Housing and Urban Development:

- New communities loan guarantees

Department of the Interior:

- Bureau of Indian Affairs loan guarantee program
- Guarantee of certain obligations of the Guam Power Authority
- Guarantee of Virgin Islands bonds
- Guarantee of Virgin Islands loans

Department of State:

- Agricultural and productive credit and self-help community development program
- Housing guarantee program

Department of Transportation:

- Aircraft loan guarantee program
- Emergency Rail Services Act of 1970 guarantee of trustee certificates
- Loan guarantees issued under the Rail Passenger Service Act of 1970
- National Capital Transportation Act revenue bond guarantee program

Department of the Treasury:

- Emergency Loan Guarantee Board

Environmental Protection Agency:

- Loan guarantees for construction of treatment works

Export-Import Bank:

- Cooperative financing facility (CFF) - participating financial institution guarantees and guarantees on certificates of loan participation
- Financial guarantees
- Medium-term commercial bank guarantees

General Services Administration:

- Federal building loan guarantees
- Real property guarantees

Overseas Private Investment Corporation:

- Investment guarantees

Small Business Administration:

- Air pollution control loans
- Base closing economic injury loans
- Coal mine health and safety loans
- Displaced business loans
- Economic injury disaster loans
- Economic opportunity loans
- Emergency energy shortage economic injury loans
- Handicapped assistance loans
- Meat and poultry inspection loans, consumer protection loans
- Occupational safety and health loans
- Physical disaster
- Regular business loans
- Small business investment company program
- Surety bond guarantee
- Strategic arms economic injury loans
- Water pollution control loans

United States Railway Association:

- Interim maintenance and improvement loans
- Loans for railroads in reorganization
- Loans to State, local, or regional transportation authorities

Veterans Administration:

- Veterans housing loans
- Veterans mobile home loans

FEDERALLY INSURED LOAN PROGRAMS

Department of Agriculture:

- Association irrigation and drainage loans
- Business and industrial loans
- Community facilities loans
- Domestic farm labor housing loan program
- Farm emergency loan program
- Farm operating loans
- Farm ownership loans
- Grazing association loans
- Indian tribes and tribal corporation loans
- Individual homeowners loans, loans for housing and buildings on potentially adequate farms
- Recreation facilities loans
- Resource conservation and development loans
- Rural electrification loans
- Rural housing disaster loans
- Rural housing site loans
- Rural rental housing loans
- Rural telephone loans
- Soil and water conservation loan and loan insurance program for individuals
- Very-low income housing repair loans
- Watershed protection and flood prevention loans

Department of Health, Education, and Welfare:

- Student loans

Department of Housing and Urban Development:

- Homes for certified veterans
- Mortgage insurance for home purchases
- Homes for disaster victims
- Homes in outlying areas

Home improvement loan insurance for housing outside urban renewal areas
 Mobile home parks
 Mortgage insurance for rental housing
 Development of sales-type cooperative projects
 Investor-sponsored cooperative housing
 Management type cooperative projects
 Mortgage insurance for purchase of sales-type cooperatives
 Cooperative housing insurance, management type projects – supplementary
 loans
 Homes in urban renewal areas
 Mortgage insurance for rental housing in urban renewal areas
 Homes for low- and moderate-income families
 Mortgage insurance for rental housing for low- and moderate-income families
 Mortgage insurance for rental housing for moderate-income families
 Rehabilitated housing for low-income families
 Conversion of rental housing projects to condominiums
 Conversion of rental housing projects to cooperatives
 Mortgage insurance for servicemen
 Housing in older, declining areas
 Mortgage insurance for the purchase or refinancing of existing multifamily
 housing projects
 Mortgage insurance for rental housing for the elderly
 Mortgage insurance for nursing home and intermediate care facilities
 Mortgage insurance for experimental homes
 Mortgage insurance for experimental projects other than housing
 Mortgage insurance for experimental rental housing
 Mortgage insurance for purchase of units in condominiums
 Construction or rehabilitation of condominium projects
 Homes for lower-income families
 Acquisition and rehabilitation of homes for resale to lower-income families
 Purchase of rehabilitated homes by lower-income families
 Rental and cooperative housing for lower-income families
 Mortgage insurance for special credit risks

Mortgage insurance for purchase by homeowners of fee simple title from lessors
Multifamily coinsurance
Single-family coinsurance
Experimental financing graduated payment
Armed services housing for civilian employees
Historic preservation loans
Mobile home loan insurance
Section 2 - Property improvement loan insurance for improving all existing
structures and building new nonresidential structures
Title X - Land development and new communities
Title XI - Group practice facilities

Department of the Interior:

Bureau of Indian Affairs loan insurance program

Export-Import Bank:

Medium-term export credit insurance
Short-term export credit insurance

Veterans Administration:

Veterans housing loans
Veterans mobile home loans

APPENDIX C
INTERESTED PARTIES

APPENDIX C

INTERESTED PARTIES

* Advanced Mechanical Technology, Inc.
Dr. Walter Syniuta * American State Bank
Mr. William Dean * American Transit Corp.
Mr. Paul Ballard * Atlantic Richfield Co.
Mr. William Schlarb * Autotronic Controls Corp.
Mr. Jack Priegel * Bache, Halsey, Stuart, Shields, Inc.
Mr. George Reis * Bales-McCoin Tractionmatic, Inc.
Mr. Kent Bales Bankers Trust Co.
Mr. Daniel F. D. McKinley * Battelle Columbus Lab.
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Mr. Lawrence Fitch * Detroit Diesel Allison - General Motors
Mr. Dan Johnson * ERG, Inc.
Mr. Glendon Benson * Falcon Research and Development Co.
Mr. H. T. McAdams Ford Motor Co.
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Mr. Ross Olander * H. Y. and Associates, Inc.
Mr. P. J. Walsh * Ideal Corp.
Mr. David Reiss * Kinergy Research and Development
Ms. Laura Ormhundro * Kumm Ind.
Mr. Emerson Kumm |
|--|---|

* Represents those interested parties which indicated an intent to attend a discussion session.

- * Lehman Brothers, Kuhn, Loeb, Inc.
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- * Manufacturers Hanover Trust Co.
Mr. T. David Quarles
- * Math Sciences Northwest
Mr. Robert Taussig
- * Mechanical Technology, Inc.
Mr. Otto Decker
Merrill, Lynch, Pierce, Fenner,
and Smith, Inc.
Mr. Gordon Watson
- * Miller Electric Manufacturing Co.
Mr. Jack Hanus
- * Monsanto Co.
Mr. F. H. Langenfeld
- * Onan Corp.
Mr. Peter Cerf
- * Peco Enterprises, Inc.
Mr. Frank Granados
- * Peterbilt Motors Co.
Mr. Virgil Pound
- * Philips Lab.
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- * Power-Matic Corp.
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Dr. Andrew Frank
- * Virginia Polytechnical Institute
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W. Dobbs and Co.
Mr. Nelson Taylor
- * Walker Manufacturing Co.
Mr. Robert Balluff

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Dr. T. Singh
- * White Engines, Inc.
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APPENDIX D
POINTS OF CONTACT

APPENDIX D

POINTS OF CONTACT

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University of Santa Clara Dr. P. Delescu	Ford Motor Company Mr. D. Ranzi
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Securities & Exchange Commission Division of Corporate Finance Mr. John Mooney	Securities & Exchange Commission Division of Economic Research Mr. Paul Livingston
Federal Reserve System Division of Research and Statistics Mr. Paul Boltz	Comptroller of the Currency Bank Organization and Structure Mr. Hugh Eggleton

Federal Deposit Insurance Company
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Government Guaranteed Loan Dealers
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Corning Glass Company
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GTE---Sylvania
Mr. Irvin Erickson

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Public Securities Association
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Orshanky Transmission Corporation
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