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Series: Sununu, John, Files
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OA/ID Number: 29155
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Folder Title:
National Energy Strategy (2 of 2) 1991 [3]

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Withdrawal/Redaction Sheet
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Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01. Memo	From Ede Holiday to John Sununu Re: National Energy Strategy (NES) Implementation (2 pp.)	6/19/91	P/5	

Collection:

Record Group: Bush Presidential Records
Office: Chief of Staff, White House Office of
Series: Sununu, John, Files
Subseries: Issues Files
WHORM Cat.:
File Location: National Energy Strategy (2 of 2) 1991 [3]

Open on Expiration of PRA
(Document Follows)
By ff (NLGB) on 10/28/05

Date Closed:	1/5/2005	**OA/ID Number:**	29155-001
FOIA/SYS Case #:	1998-0004-F[2]	**Appeal Case #:**	
Re-review Case #:	2005-0426-S	**Appeal Disposition:**	
P-2/P-5 Review Case #:		**Disposition Date:**	
AR Case #:		**MR Case #:**	
AR Disposition:		**MR Disposition:**	
AR Disposition Date:		**MR Disposition Date:**	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

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Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

AC/ER

THE WHITE HOUSE

WASHINGTON

June 19, 1991

THE CHIEF of STAFF
has seen

MEMORANDUM FOR GOVERNOR SUNUNU

FROM: EDE HOLIDAY

SUBJECT: National Energy Strategy (NES) Implementation

The working group on NES executive branch initiatives met today. At your request, the group has been monitoring and coordinating agency activities so that the Administration would establish a solid record of accomplishment, while Congress deliberates energy legislation.

I thought it might be helpful to give you a brief summary of NES activities that have taken place since the strategy was released on February 20. Most significant are the following:

o The President signed an Executive Order on Federal Energy Management on April 17. The Executive Order directed Federal agencies to take cost-effective steps to reduce energy consumption in Federal buildings and facilities by 20% by the year 2000 and fuel consumption in Federal vehicles by 10% by the year 1995.

o The IRS issued rules on May 17 that would increase the amount of tax-free mass transit benefits that employers may provide to employees. The rules would raise this amount from the current $15 per month to $21 per month.

o The IRS issued rules on June 11 providing that utility rebates for consumers who participate in conservation programs are not taxable income. The IRS ruling conforms with the Administration's position that the rebates must be tied to the consumers electricity bill.

o FERC issued new regulations on May 8 to improve the licensing procedures for expanding capacity at existing hydropower sites.

o The Western Area Power Administration published a notice of a proposed energy management program to foster integrated resource planning in PMAs. Public hearings are currently being scheduled.

o DOE completed its rulemakings on test procedures for fluorescent light ballasts and on efficiency standards for cleaning products.

o As provided for in the NES, DOE has established task forces to resolve or address certain policy or regulatory issues affecting a broad range of Federal and State interests. During the next two weeks, the following priority task forces will meet:

--task force on Alaska North Slope technical and regulatory barriers

--task force on the impact of environmental rulemakings on energy supply

--task force on radionuclide regulation

--task force on energy efficient housing

In addition to the these initiatives, a number of other items are being scheduled for activity during the summer months. Most significant are the following:

o DOE has received a proposal from the United States Advanced Battery Consortium (led by the big three automakers) whereby the Administration would support the multi-industry consortium through research grants and sharing scientists from the National Laboratories. DOE will begin negotiating with the consortium later this month and expects to enter into an agreement with the consortium in September.

o A Presidential finding on the export of California heavy crude oil will be submitted by Commerce for Presidential approval in July, provided that our legislative assessment suggests moving forward.

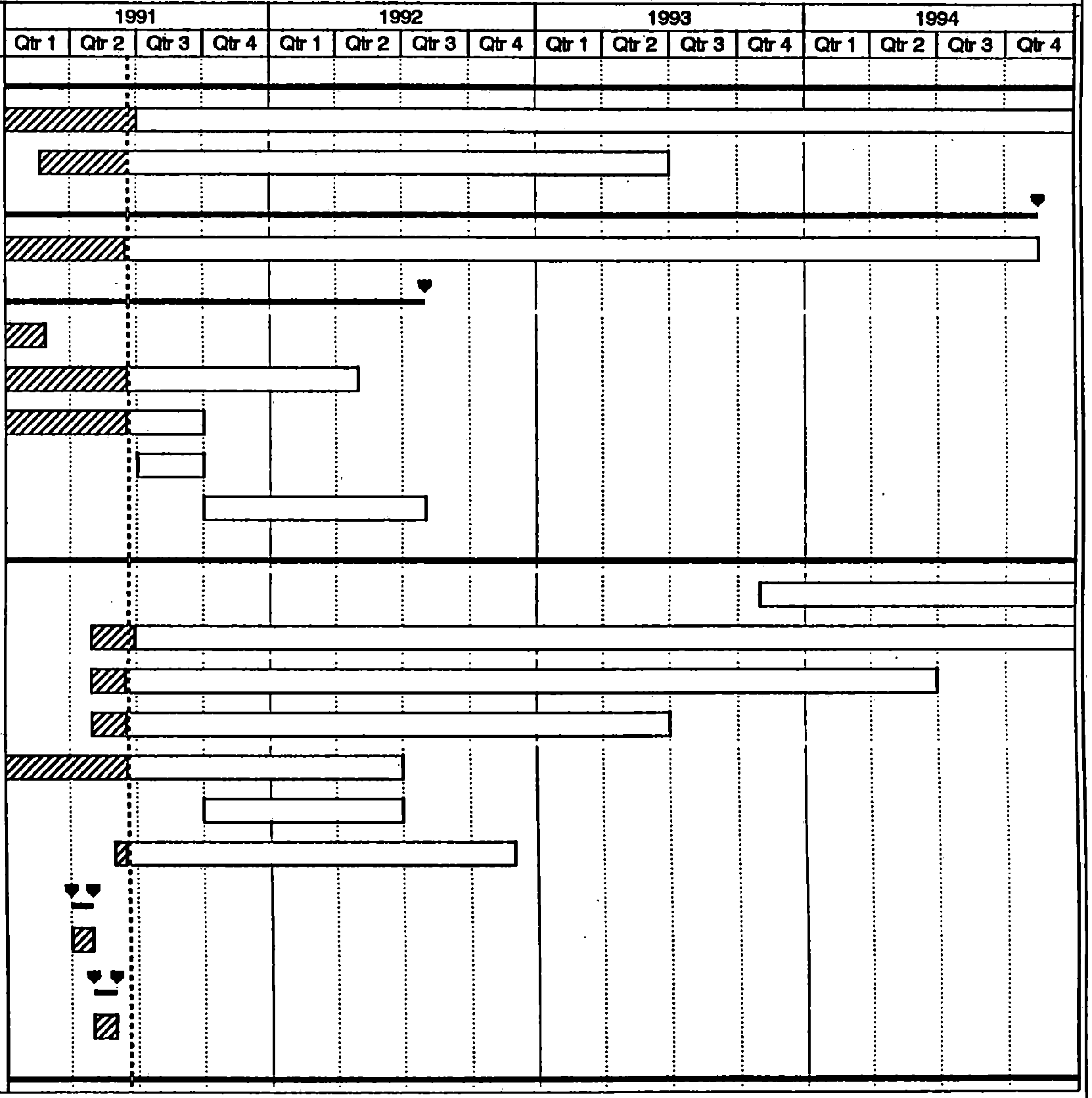
o A Presidential dedication ceremony of the Solar Energy Institute (SERI) in Colorado as the National Renewable Energy Laboratory is being considered.

For your information, DOE has prepared an elaborate internal tracking system that sets out milestones and a timeline for each NES executive branch initiative. I have attached this status report, which indicates the degree of attention that DOE is giving the NES proposals.

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
1	**Increase Federal Energy Efficiency**
1.1	Executive Order
1.2	Establish Federal Energy Efficiency Fund
2	**Improve Energy Efficiency of Public Housing**
2.1	Publish Multiyear Plan
4	**Total Fuel-Cycle Costs**
4.1	Phase I: Research Design/Definition, and Agreements
4.2	Phase II: The Accounting Framework Analysis
4.3	Phase III: Exploring the Requirements of an E Systems Analysis
4.4	Phase IV: Identify Remaining Critical Issues and Needs
4.5	Phase V: Comparison of Counterpart Studies and Final
5	**Set Appliance and Equipment Standards**
5.1	Rulemaking for Cleaning Products Standards
5.2	Rulemaking for Nine Product Standards
5.3	Rulemaking for Central Heating and Cooling Products Stds.
5.4	Rulemaking for Seven Products Test Procedures
5.5	Lighting Study
5.6	Extension of Testing
5.7	Rulemaking for Refrigeration Product Standards
6	**Improve Energy Efficiency Information to Consumers**
6.1	Buildings Program Briefing for Support Office Personal
7	**Treat Efficiency Discounts By Utilities as Tax Free**
7.1	IRS Prepares Technical Advice Memorandum (TAM)
8	**Promote IRP within States**



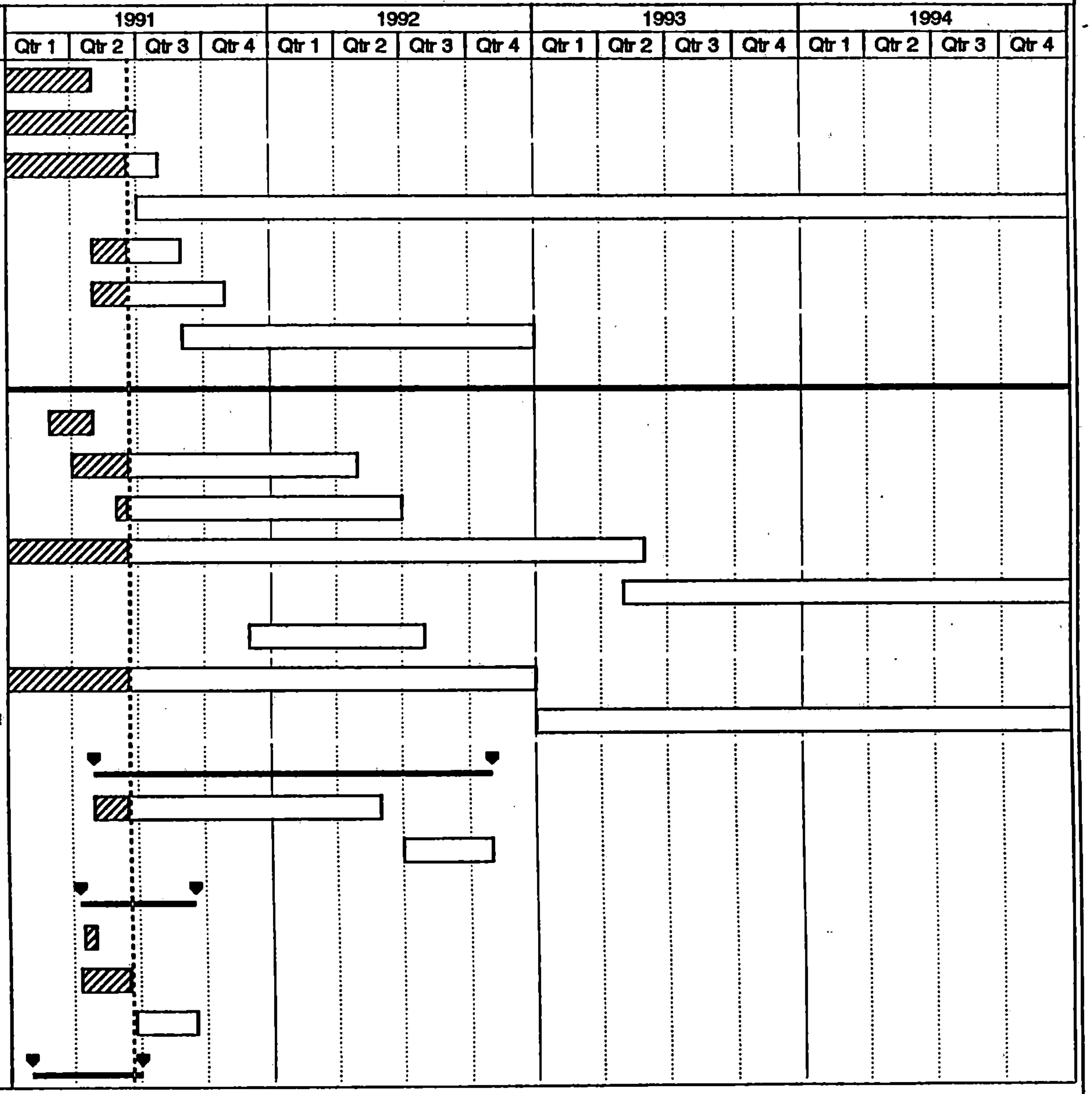
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary ♥―――♥

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
8.1	Co-Sponsor and Participate in NARUC IRP Conference
8.2	Collaborate with EPA to Assist in Preparation of Draft Regulations for I
8.3	Co-Sponsor and Participate in 5th National DSM Conference
8.4	Conduct Analyses Leading to Regional IRP Planning in Two Regions
8.5	Co-Sponsor and Participate in 5th International Energy Program Evalu
8.6	Total Fuel Cycle Analysis Overview for the Electric Utility Sector
8.7	Develop Handbook on Gas IRP Initiative to Facilitate State Adoption
9	**Foster IRP in Federal PMA's**
9.1	WAPA: Federal Register Notice of Proposed Energy Mgmt Program
9.2	WAPA: Conduct Public Meetings on Proposed Program
9.3	WAPA: Prepare IRP Workbook
9.4	WAPA: IRP Regulation Issued
9.5	WAPA: IRP Regulation Final Implementation Begins
9.6	BPA: Develop 1992 Resource Program Plan
9.7	SEPA, SWPA, APA: Assess IRP Opportunities
9.8	SEPA, SWPA, APA: Assess Implementation of IRP Facilitation Progr
10	**Foster IRP Through FERC Regulation of Wholesale Power Markets**
10.1	Establish Joint DOE/FERC Working Group
10.2	Report on DOE/FERC Working Group
11	**Expand Access to Electricity Transmission**
11.1	DOE Presents Testimony on Transmission Issues at House Hearing
11.2	FERC Announces Public Conference on Election Issues
11.3	DOE, FERC, and Interested Admin. Agencies Decide Next Step
12	**Promote Mass Transit/Ridesharing Through Tax Free Subsidies**



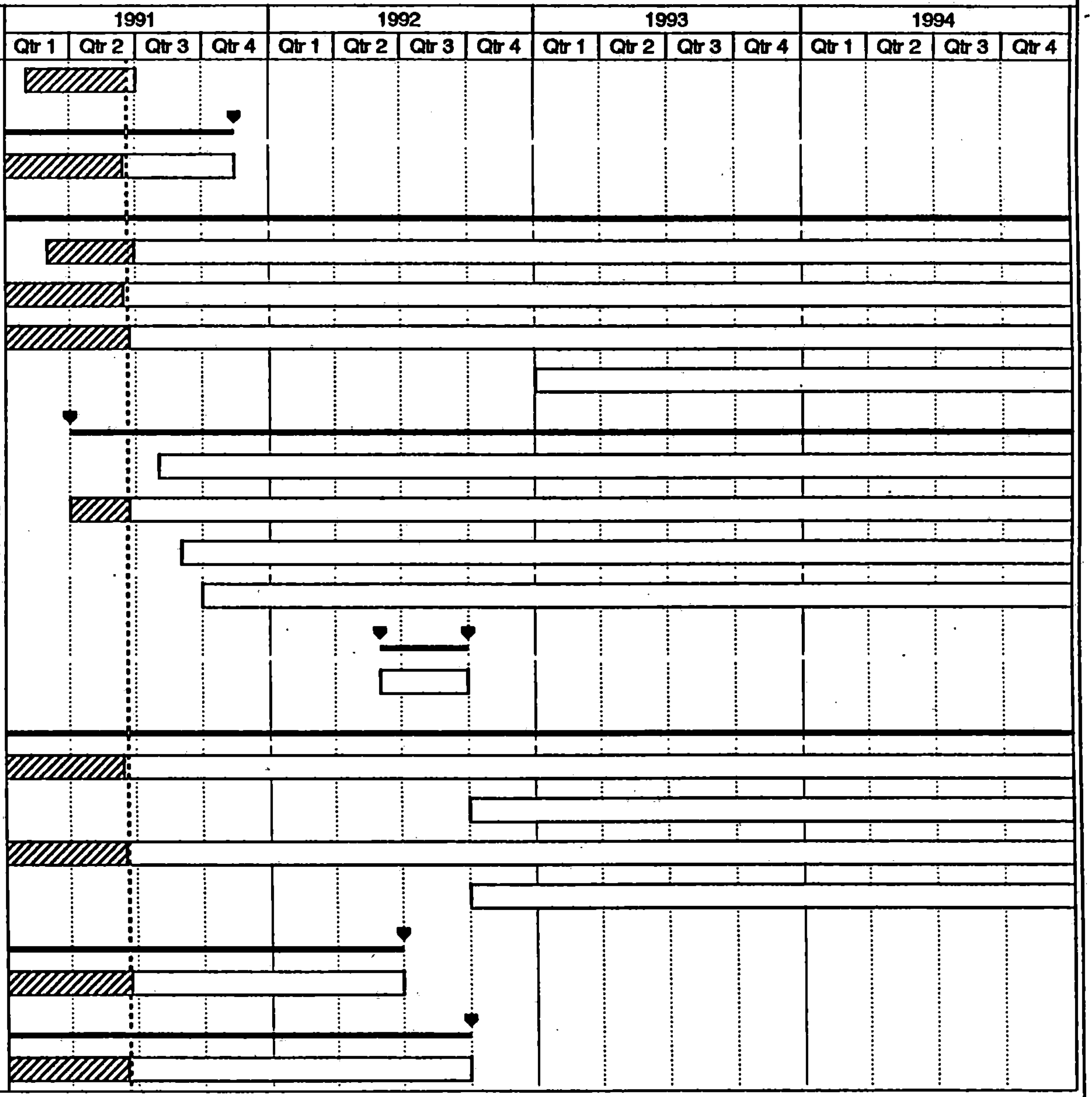
Project: NES Administrative Actions
Date: 6/18/91

Schedule ▭ Progress ▨ Summary

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
12.1	Issue Amended IRS Regulations
13	**Accelerate Scrappage of Old Cars**
13.1	Issue Technical Guidance Document
14A	**Increase R&D for Advanced Heat Engine Propulsion**
14A.1	Demonstrate AGT Readiness
14A.2	Demonstrate LHR Diesel Engine
14A.3	Develop Capability for Automated Mftg. of Stuctural Components fc
14A.4	Develop Extreme Environ. Lubricants for Adv. Heat Eng.
14B	**Increase R&D for Electric and Hybrid Propulsion**
14B.1	Achieve Tech. Readiness for Mid-Term Battery System
14B.2	Complete Eval. of Phosphoric Acid Fuel Cell/Battery Hybrid Bus Sy
14B.3	Complete Devlpmt. and Eval. of PEM Fuel Cell Transport Propulsic
14B.4	Complete Development of Mod. Elec. Propulsion System
15	**Pursue High-Speed Rail and MAGLEV Initiatives**
15.1	Prepare Joint FRA/COE/DOE Decision Report
16	**Enhance R&D for Efficient Aircraft Engines and Fuselages**
16.1	Component Level Material Performance Verification
16.2	Hybrid Laminar Flow in Board Wing Glove Flight Experiment
16.3	Large Scale Composite Components Structural Performance Verificati
16.4	Ground-based Evaluation on Integrated FBL/PBW System
17	**Expand Use of Intelligent/Vehicle Highway Systems**
17.1	Strategic Plan for IVHS Development and Implementation
18	**Increase Efficiency in Air Traffic Control Systems**
18.1	Complete Development of HARS



Project: NES Administrative Actions
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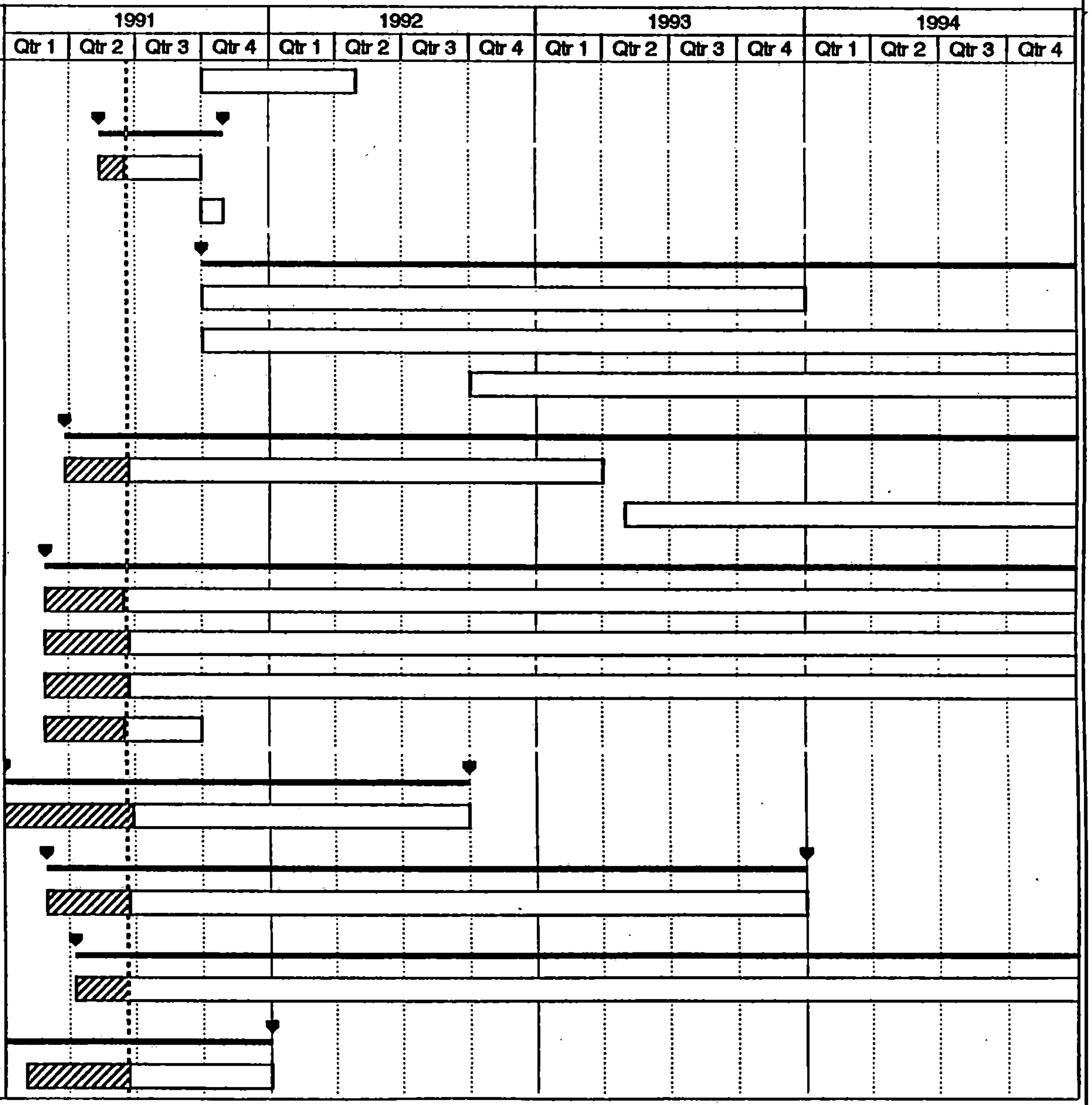
Schedule ☐ Progress ▨ Summary

NES Administrative Ac .s Tracking System

Status as of June 18, 1991



No.	Administrative Action
18.2	Complete Deployment of DOTS
19	**Evaluate CAFE Standards**
19.1	Receive Report from NAS
19.2	Submit Recommendations to Congress
20	**Increase R&D on Telecommuting**
20.1	Develop Prototype WAN Packet
20.2	Develop LAN Oriented Packet
20.3	Work with Industry to Develop Workstation Based Desk Top Multi-Mec
21	**Expand Mortgage Finance Incentives for Efficient Homes**
21.1	Develop Home Energy Rating Procedures
21.2	Provide Assistance to Org. Requesting Aid in Implementing Home Ene
22	**Develop Model Standards for Building Efficiency**
22.1	Commercial and Multi-Family High Rise Residential Standards
22.2	Single family and Multi-Family Low Rise Residential Standards
22.3	Federal Programs
22.4	Monitor Implementation, Enforcement, and Effectiveness of Standards
23	**Increase R&D on Waste Minimization**
23.1	Minimize Industrial Waste
24	**Increase R&D on Industrial Process Efficiency**
24.1	Improving Energy Efficiency and Fuel-Flexibility
25	**Expand Industrial Energy Audits**
25.1	Energy and Industrial Audits
27	**Increase R&D on Renewable Technology**
27.1	Develop and Adopt Program Plan for Increased R&D of Renewable Te

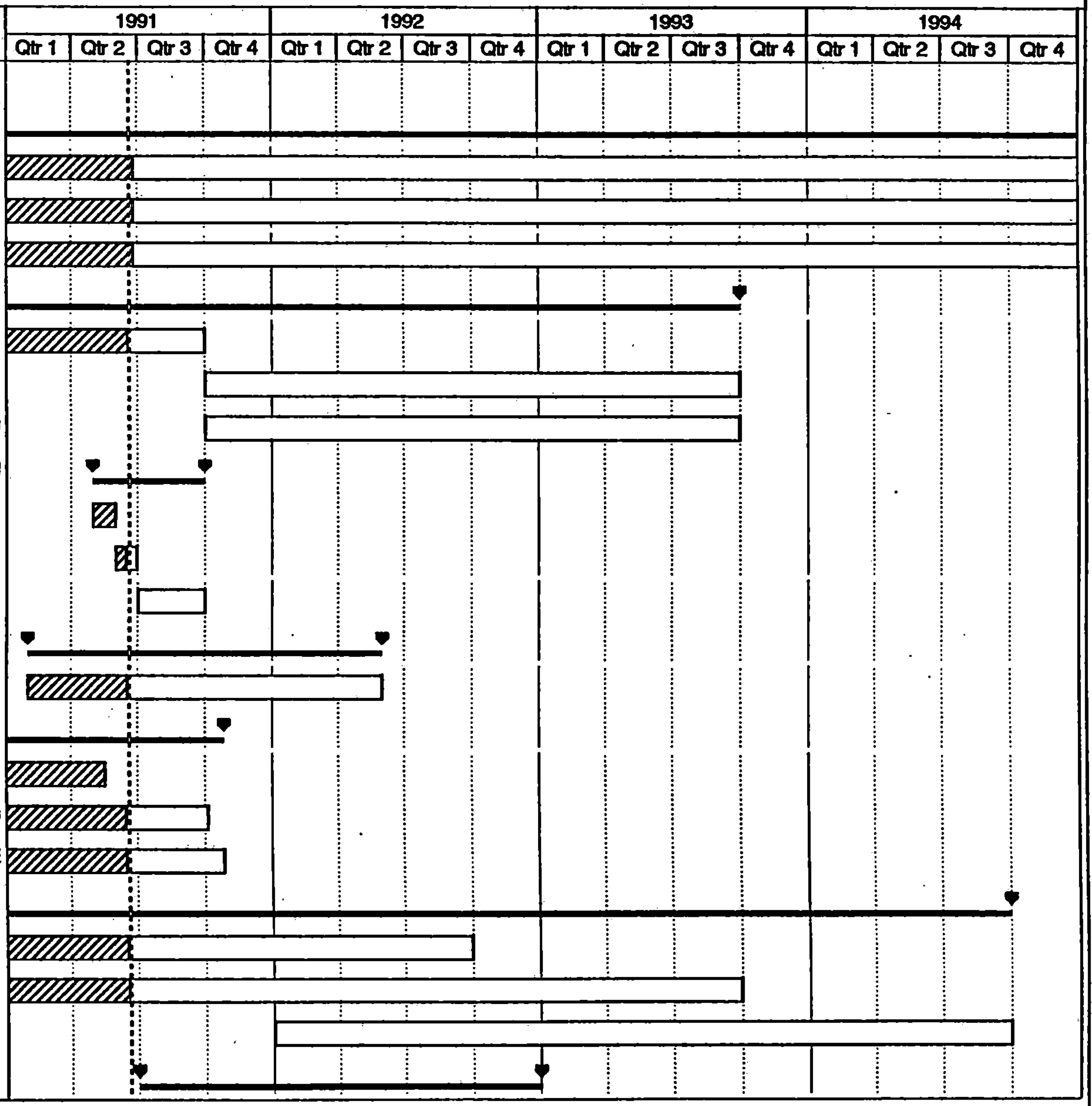
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
27.2	Annually, Develop and Adopt MYPP for Continuing Program of Increas
28	**Increase R&D on Biomass Fuels and New Energy Crops**
28.1	Develop New Energy Crop(s) at $2.00/Million Btu ($34/dry ton)
28.2	Cost-Competitive Ethanol ($0.80/gallon gasoline equivalent wholesale)
28.3	Cost-Compteive Methanol ($0.80/gallon equivalent wholesale)
29	**Conduct Environmental Research Related to Hydropower**
29.1	Complete Research on Phase I Mitigation Studies
29.2	Initiate Phase II Mitigation Studies
29.3	Initiate Development of Improved Environ. Eval. Criteria and Methodol
30	**Improve the Licensing Procedure for Expanding Capacity at Existing**
30.1	FERC Issues New Regulations
30.2	Send Letter Requesting FERC to Upgrade Non-Federal Projects
30.3	FERC Chairman Advises Secretary of Implementation Schedule
31	**Increase Use of Municipal Waste-To-Energy Technology**
31.1	Convert Municipal Solid Waste to Energy
32	**Encourage Export of Renewable Energy and Efficiency Technology**
32.1	Trade Show (Guam)
32.2	U.S. Export Council for Renewable Energy (US ECRE) Pacific Rim Tr
32.3	Financing of Energy Servces for Small Scale Energy Users (FINESSE
33	**Purchase More Alternative-Fuel Vehicles for Federal Use**
33.1	1% of Fed. Fleet Procurements Alternative Fueled
33.2	5% of Federal Fleet Procurements Alternative Fueled
33.3	10% of Federal Fleet Procurements Alternative Fueled
34	**Increase Oil Production Outside the Persian Gulf**



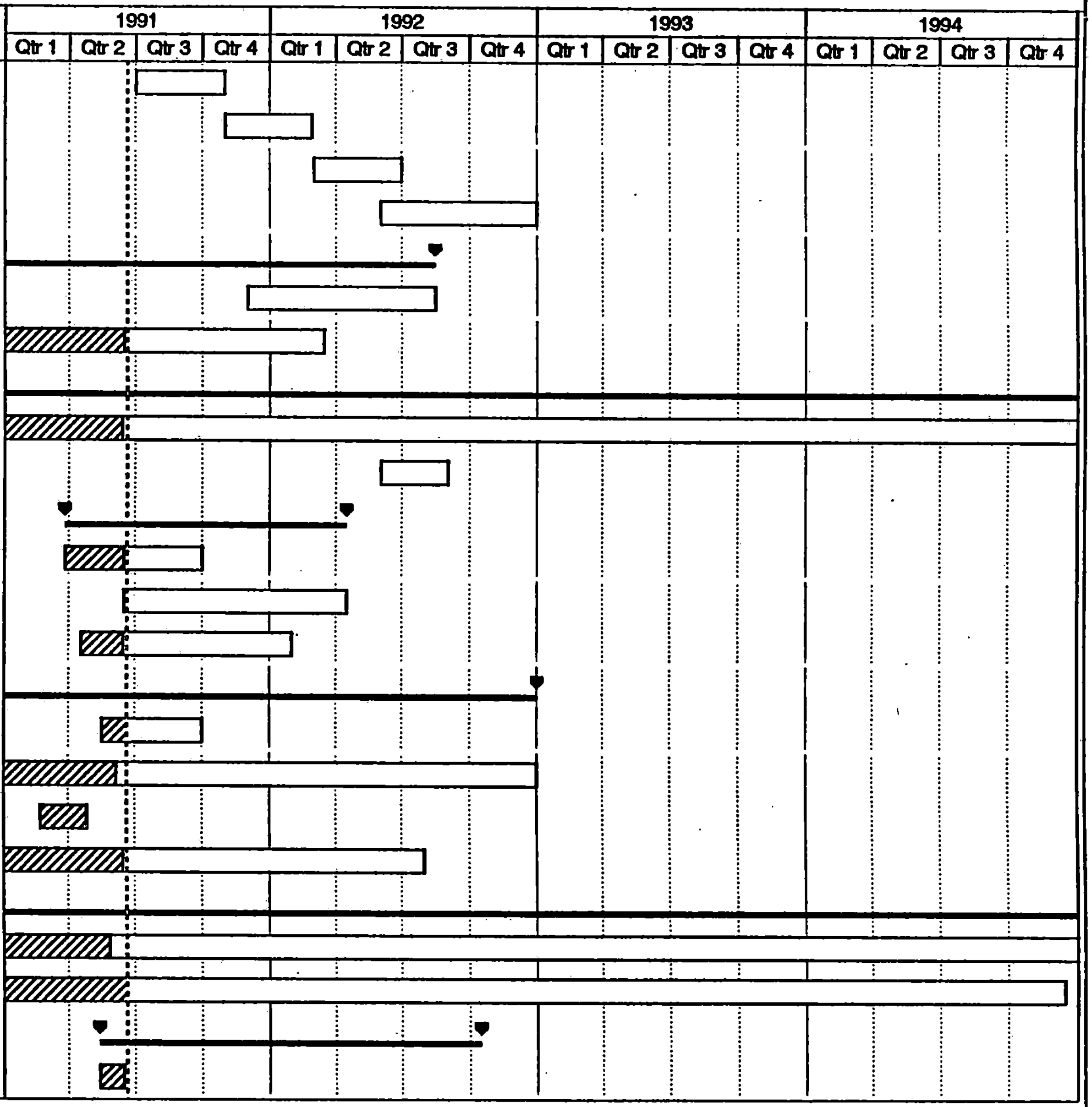
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative A ıs Tracking System

Status as of June 18, 1991

No.	Administrative Action
34.1	Develop a Prioritized List of Countries
34.2	Repeal Laws Hampering Foreign Trade and Investment
34.3	Formulate Action Plans to Raise Near Term Production
34.4	Implement Action Agenda
35	**Expand the Strategic Petroleum Reserve**
35.1	Prepare SPR Plan Amendment
35.2	Negotiate SPR Oil Supply Contracts
36	**Promote Horizontal Drilling**
36.1	Demonstrate the Applicability of Horizontal Wells to Class 1 Reservoi
36.2	DOE/States Effort to Eliminate State Regulatory Impediments to Horiz
37	**Increase Production of California Heavy Oil**
37.1	Policy to Make Sure that Requirements for Calf. Heavy Oil Will Be Met
37.2	Analysis and Report Required to Study New Nat. Gas Pipln. and EO
37.3	Fossil Energy Will Ensure that Kern-Mojave Gas Pipln. on Sched.
38	**Allow Access to Certain Outer Continental Shelf Areas**
38.1	End Congress. OCS Moratoria Beyond Pres.'s 1990 Decisions
38.2	Assess Resource Base and Environ. Effects of Develop OCS Tracts F
38.3	Consider New 5-year Plan (1992-1997) Leasing OCS Areas in Enviro
38.4	Develop Leg. Initiative for Greater Revenue Sharing and Influence in C
39	**Increase R&D on Advanced Oil Recovery**
39.1	Expand the Nation's Econ. Recoverable Oil Reserves
39.2	Advanced Research
40	**Increase Oil Production from the Alaskan North Slope**
40.1	A Decision Paper for Henson Moore of Org. of a Gov. - Industry Task



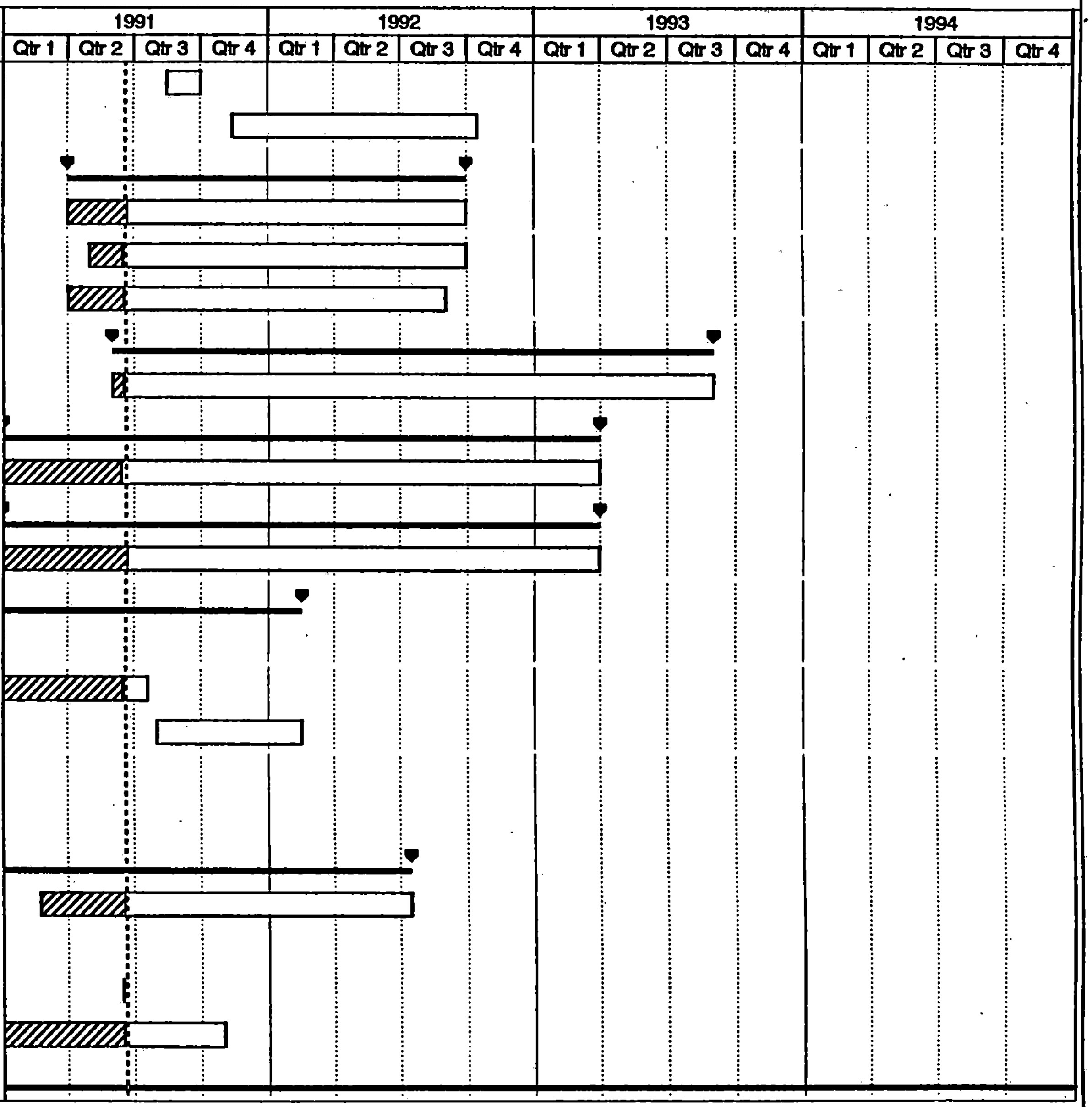
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
40.2	The Asst. Sec. for Fossil Energy Request for Participation in Task For
40.3	Task Force Will Periodically Meet to Identify Tech. and Regulate Barri
42	**Assess Gas Resource Base and Deliverability**
42.1	DOE/FERC Will Conduct a Joint Study To Perform a Nat. Gas Study f
42.2	PE Will Conduct a Secnd. Nat. Gas Resource Base Study Based on 1
42.3	NPC Will Study Constraints to Increase Use of Natural Gas
43	**Study Effects of State Regulation on Gas Market**
43.1	Develop Study
44	**Reform Pipeline Rate Design**
44.1	Participate in FERC Proceedings
45	**Improve Access to Pipeline Transportation Services**
45.1	Participate in FERC Proceedings
46	**Encourage Broader Use of Clean Coal Technology**
46.1	Publish Final Results From Each CCT Demo. Project
46.2	Publish Topical Reports as Cirumstances Warrant - Environ. Topical Ir
46.3	Publish Annual Program Update
46.4	Identify Project Related Events Suitable for Media Coverage
46.5	Monitor Proj. Sponr. Comm. Planning and Provide Asst. Where Fed. R
47	**Reduce Uncertainty about Environmental Contraints on Surface Mini**
47.1	Valid Existing Rights
47.2	Remining
47.3	Subsidence Due to Underground Mining
47.4	Abandoned Mine Land Reclamation Fees
48	**Improve Performance and Efficiency of Coal-Burning Technologies**



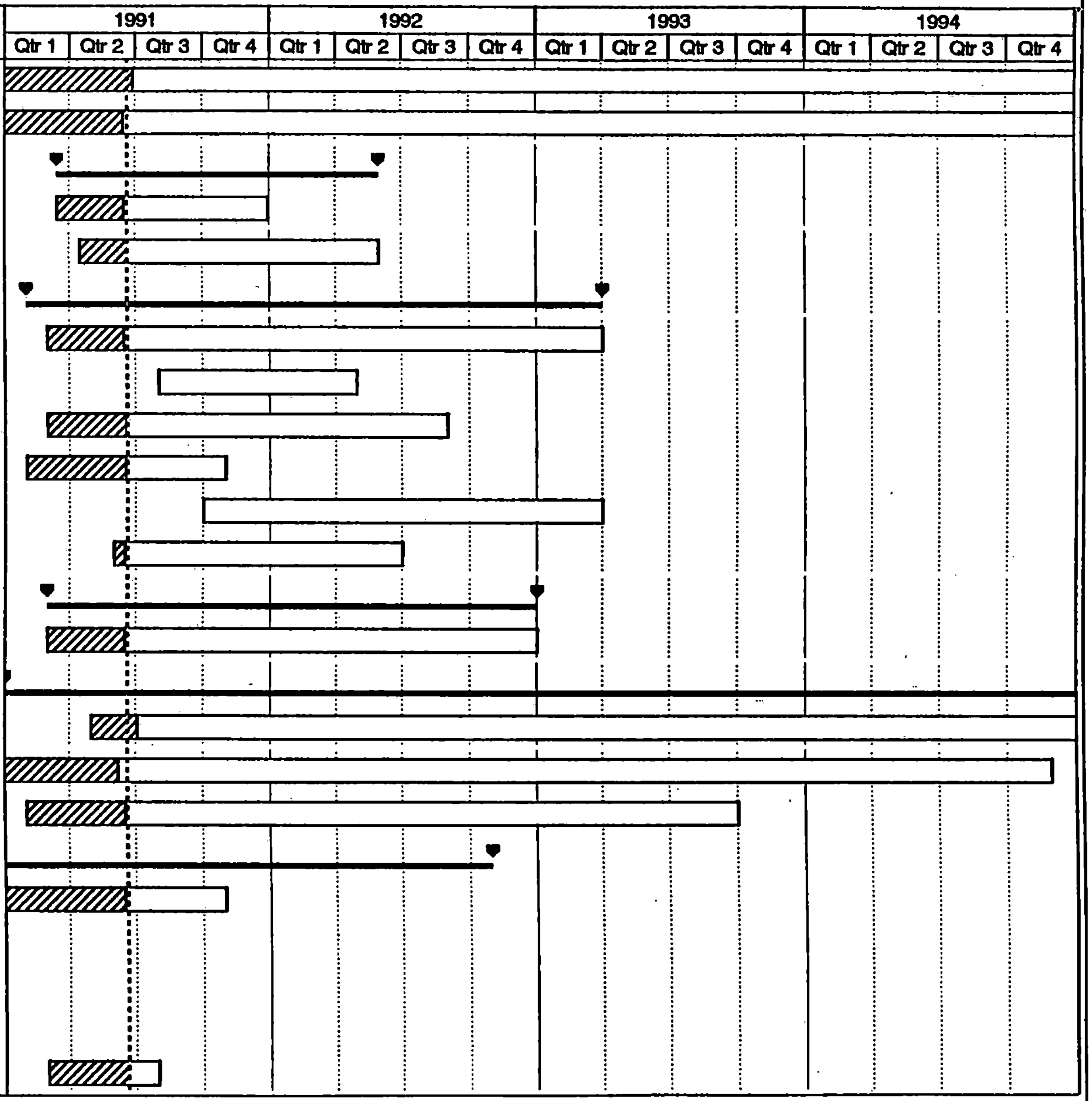
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative A s Tracking System

Status as of June 18, 1991

No.	Administrative Action
48.1	Demonstrate High Efficiency Clean Coal Power Systems
48.2	Demonstrate Super Clean Emission Processes
49	**Provide Regulatory Incentives for the Use of Clean Coal Technologie**
49.1	Argonne National Lab Incentives Study
49.2	National Regulatory Research Institute (NRRI) Study of Incentives
50	**Encourage Export of Clean Coal Technology**
50.1	Create Coal Technology Clearing House
50.2	Establish Closer Liason With U.S. Embassies
50.3	Increase Emphasis on Technologies Available for Export
50.4	Report to Congress on Promotion of CCT Exports
50.5	Study of Review Mechanisms for Financing CCT Exports
50.6	Inform U.S. Industry of Advantages of Export Trading Companies
51	**Clarify "New Source Review" Provisions for Existing Powerplants**
51.1	Adopting Interpretative of Legislative Rule for WEPCo
52	**Reduce Uncertainties Regarding CAA**
52.1	NOx Controls
52.2	Utility Toxics
52.3	Environmental Externalities
53	**Improve Public Understanding of Clean Coal Technologies**
53.1	Define Target Audiences
53.2	Interact With Audiences and Assess Info. Needs
53.3	Identify Opportunities to Disseminate Info. to Target Audiences
53.4	Expand Mailing List Data Base
53.5	Develop Plans for Future Activities



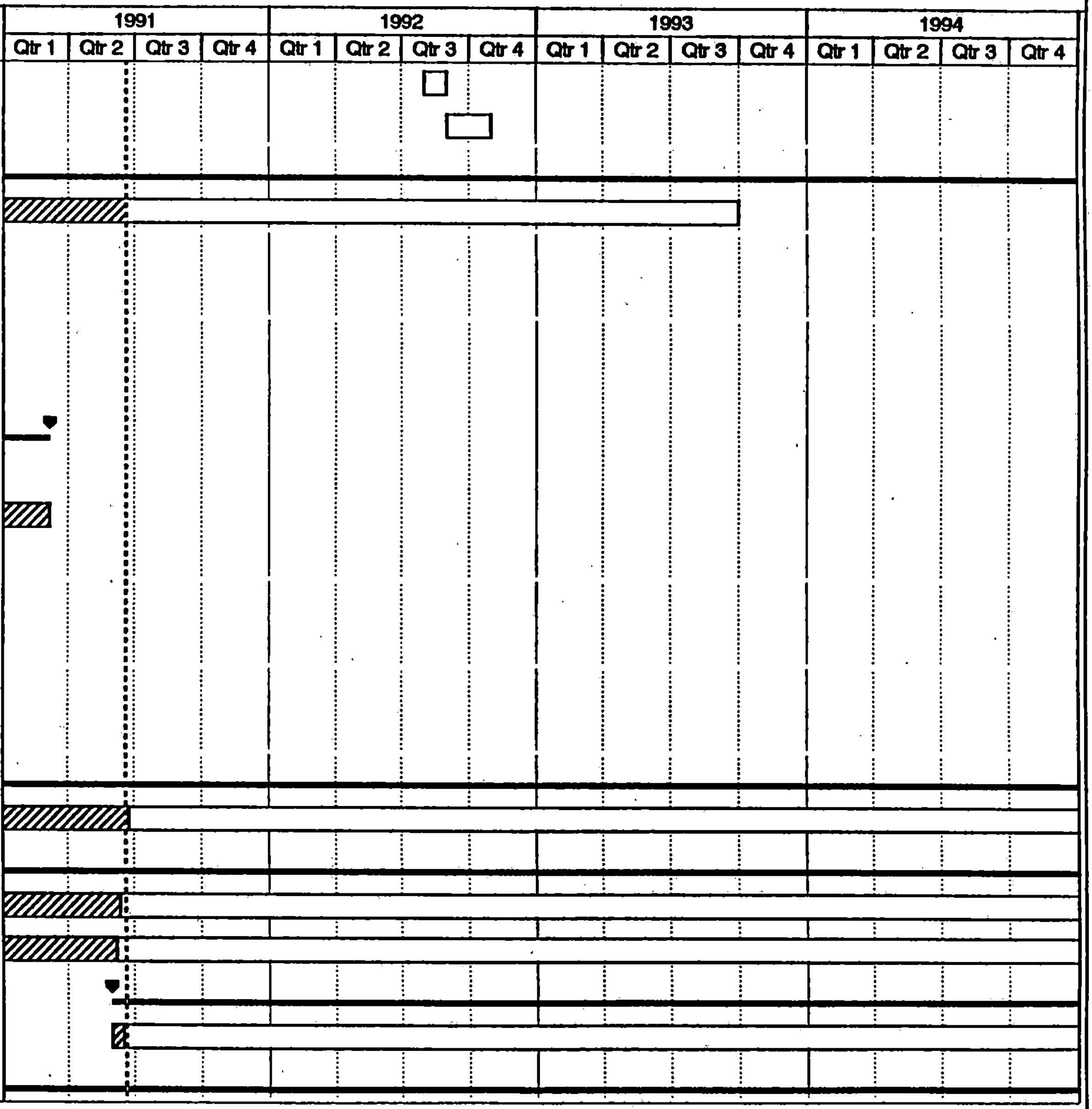
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative A s Tracking System

Status as of June 18, 1991

No.	Administrative Action
53.6	Approved Plans FY 92
53.7	Implement FY 92 Plan
54	**Conduct Research on Synthetic Liquid Fuel from Coal**
54.1	Complete Baseline Design Studies
54.2	Complete PDU Testing
54.3	Complete Baseline Design Update
55	**Ensure that the Federal Coal Leasing Program Anticipates Market Ne**
55.1	Continue to Manage the Fed Coal Mngmt. Prog. to Ensure Timely Rele
56	**Adopt Performance-Based Standards for Mine Safety and Productivi**
56.1	Noise Standards
56.2	Diesel-Powered Equipmnt. for Underground Mines
56.3	Rules of Practice for Petition for Modification of Mand. Safe. Standard
56.4	Air Quality Standards
56.5	Underground Coal Mine Ventilation
57	**Continue Ongoing R&D on New Mining Technologies and Safety Issu**
57.1	This is Ongoing R&D on Coal Mining Safety and Efficiency Issues
58	**Establish a Regulatory Process for Renewal of Existing Plant Licens**
58.1	Demonstrate Viability of License Renewal Process
59	**Demonstrate the Process of Design Certification/Early Site Approval**
59.1	Demonstrate Early Site Permit Process
59.2	Demonstrate ALWR Design Certification Process
60	**Support the Development of Commercially Standardized Designs**
60.1	Conduct First-Of-A-Kind Engineering Program to Achieve Commercial
61	**Pursue Advanced Nuclear Power Reactor Systems**



Project: NES Administrative Actions
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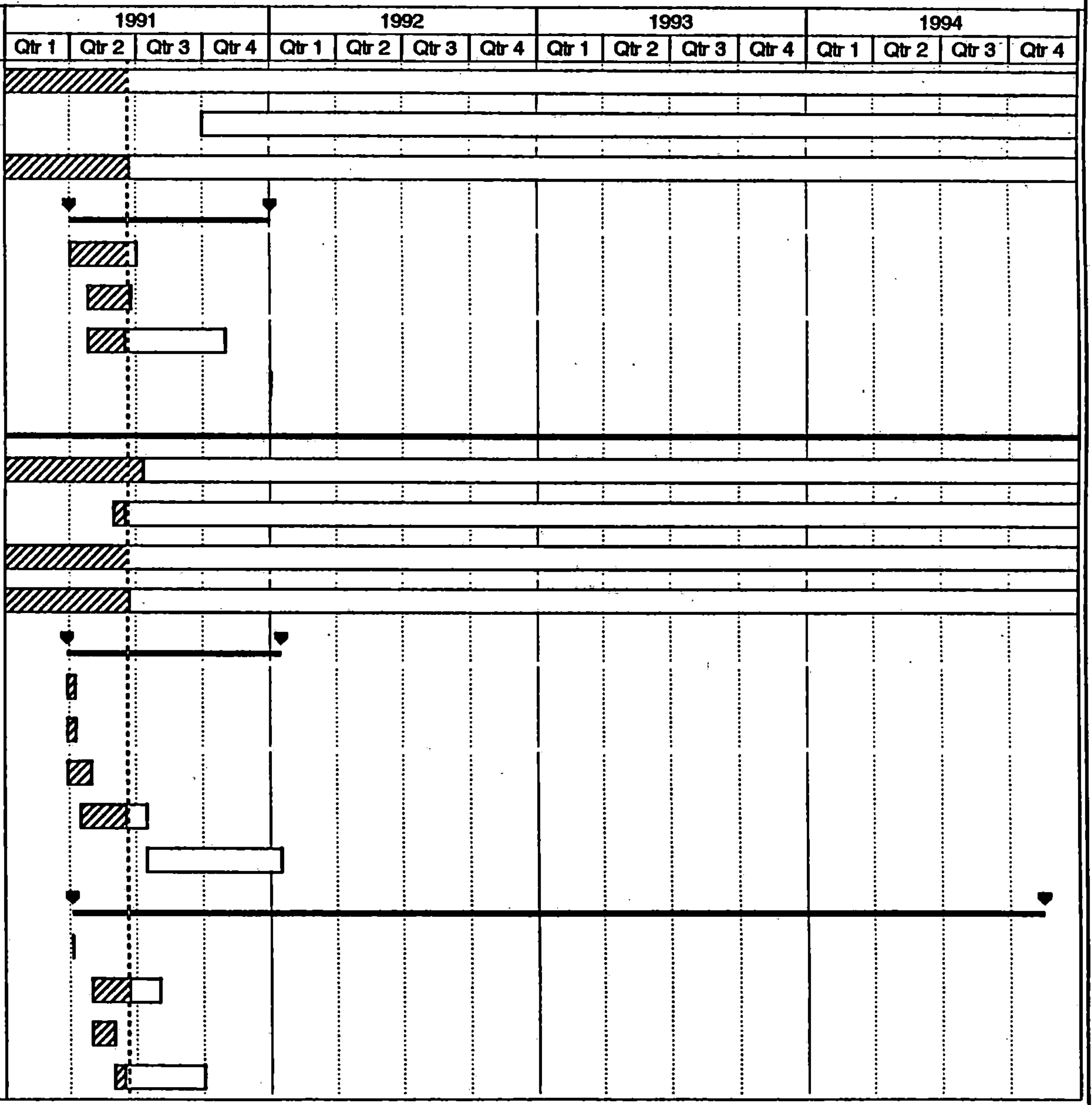
Schedule ☐ Progress ▨ Summary

NES Administrative A s Tracking System

Status as of June 18, 1991

No.	Administrative Action
61.1	Demonstrate ALWR Certification Process
61.2	Demonstrate IFR Metal Fuel Cycle
61.3	Demonstrate MHTGR Design Certification Process
62	**Expedite Safe Progress In High-Level Nuclear Waste Management**
62.1	Interagency Coordinating Committee
62.2	External Communications/Interactions
62.3	Contigency Planning
62.4	Yucca Mountain Site Characterization
63	**Develop Standardized Reactors**
63.1	Demonstrate ALWR Certification Process
63.2	Conduct First-Of-A-Kind Engineering Program to Achieve Commercial
63.3	Demonstrate ALWR Certification Process
63.4	Demonstrate MHTGR Design Certification Process
65	**Increase Use of Market Mechanisms of Environmental Rulemaking a**
65.1	Establish the DOE Waste Disposal Working Group
65.2	Establish DOE Water Quality Working Group
65.3	Establish Coordination Points With EPA and OMB
65.4	Develop First List of Legislative and Reg. Actions for Mrkt. Mechanism
65.5	Develop Updated List of Potential Actions for Mrkt Mechanisms
66	**Study Toxic Air Emissions From Utilities**
66.1	Establish Staff Contacts
66.2	EPA Initiate Planning of Studies
66.3	Establish Interagency Group Involving DOE
66.4	Complete and Review Study Plan



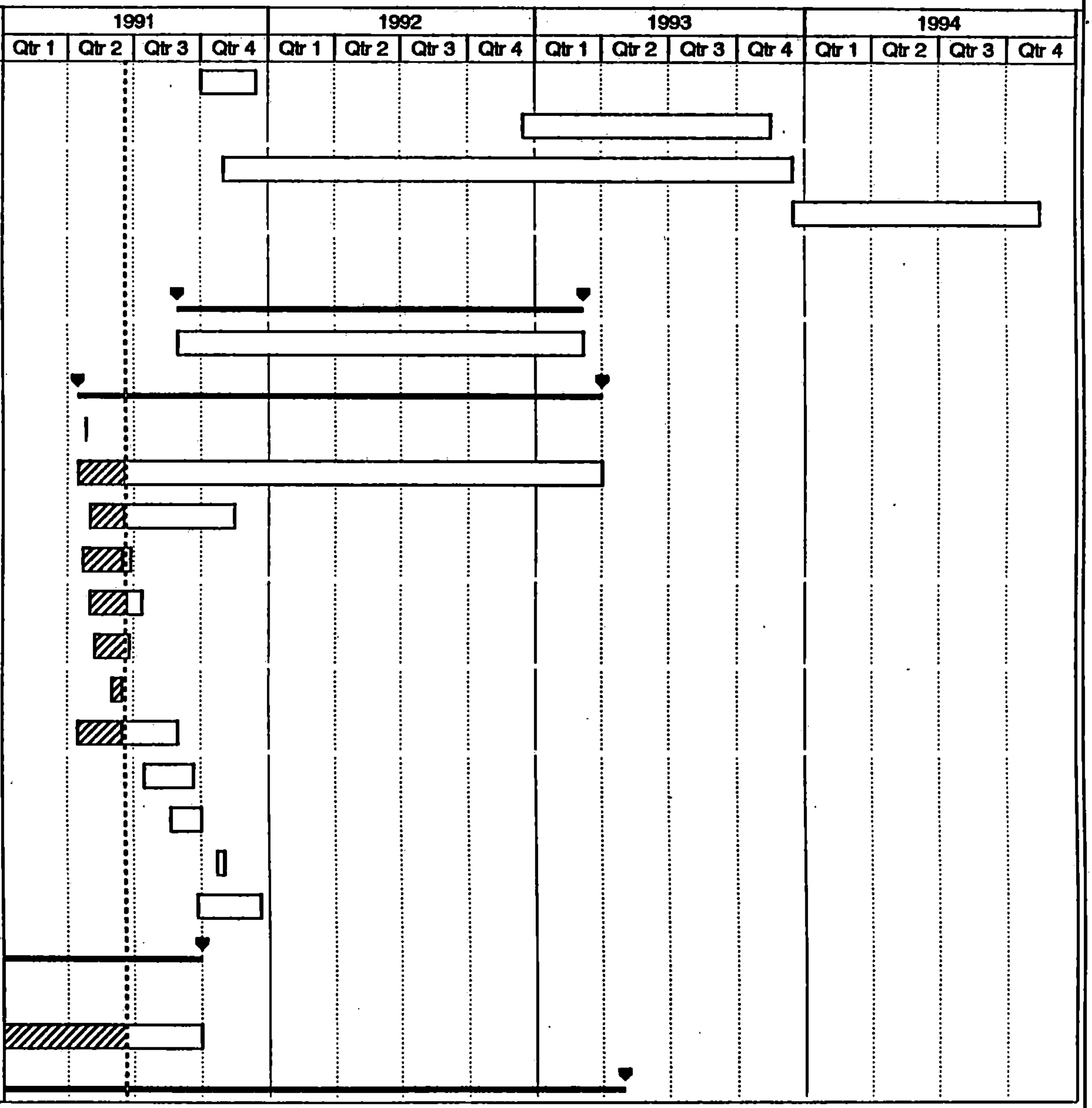
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative A s Tracking System

Status as of June 18, 1991

No.	Administrative Action
66.5	Prepare Draft Report on Air Toxics
66.6	Finalize Air Toxics Report to Congress
66.7	Prepare Draft Report on Mercury
66.8	Finalize Mercury Report to Congress
67	**Assess Radionuclide Regulatory Practices by States**
68A	**Implement the Requirements of the Oil Spill Liability Act of 1990**
68A.1	Evaluate Improvements in Fed. and Ind. Oil Spill Response Capabi
68B	**Support International Global Climate Change Processes**
68B.1	Include These Administrative Elements in the GCCEC Wrkplns
68B.2	Carry Out Intl. Technology Assessments
68B.3	Structure U.S. Emissions Inventory and Projections Study With EP
68B.4	Second Meeting of INC
68B.5	First Meeting of IPCC Emissions Task Force
68B.6	Preparation of U.S. Delegation for Vienna Convention and Montrea
68B.7	IPCC Work Group III Meeting
68B.8	3rd Prep. Meeting for UNCED
68B.9	Third INC Meeting
68B.1	6th IPCC Plenary Meeting
68B.1	IPCC Work Group III Meeting
68B.1	4th INC Meeting
69	**Assure Improvements in Global Climate Change Research**
69.1	DOE and Interagency Activities are On-Going
69.2	Prepare a DOE-Internal Study to Determine if NES Priorities are in the
70	**Assess Impact of Projected U.S. Emissions of Greenhouse Gases**



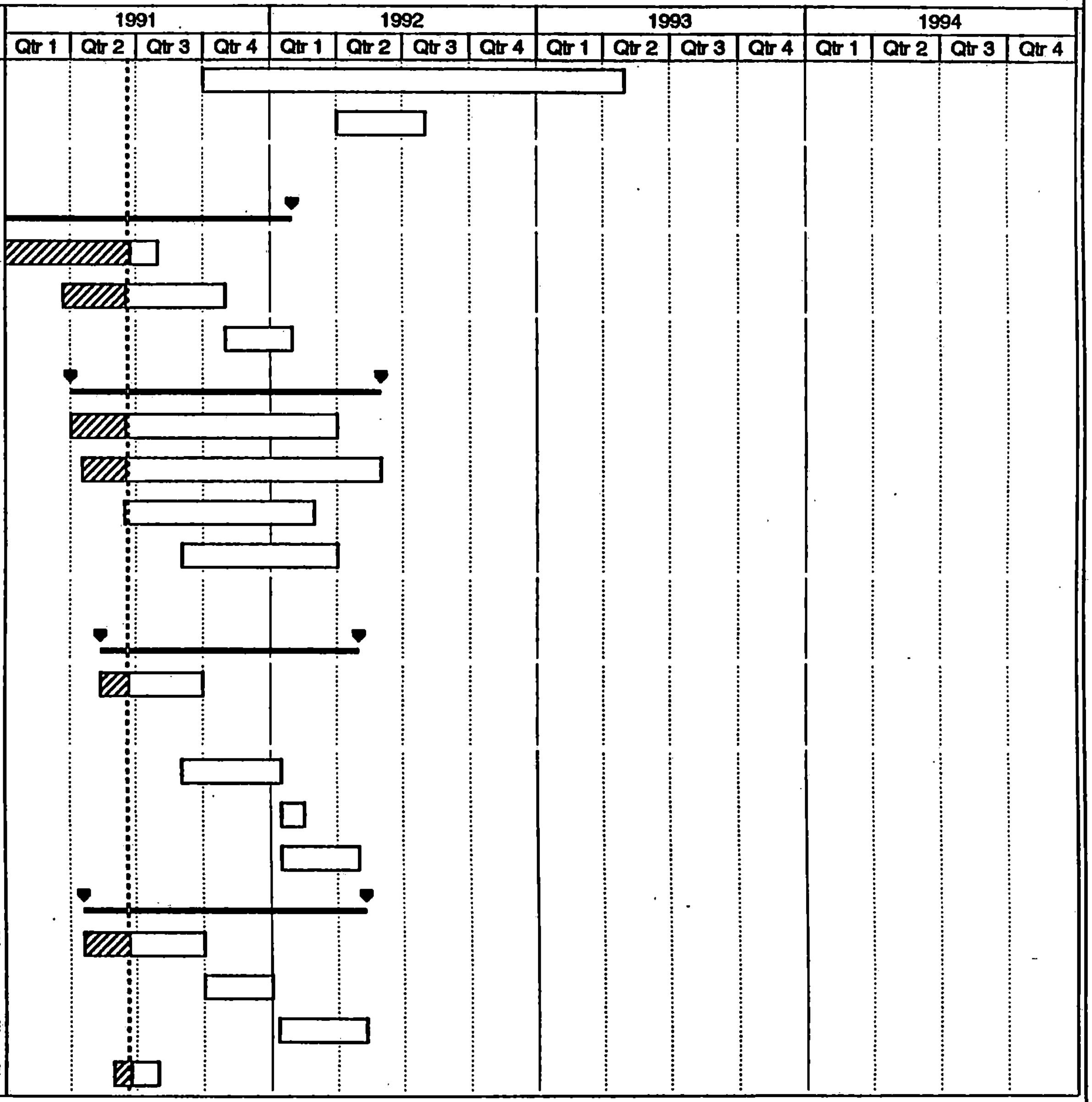
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
70.1	First Assessment Cycle Report on Projected GHG Emissions
70.2	Second Assessment Cycle Report on Projected GHG Emissions
70.3	Cycles Will Continue on a Semi-Annual Basis
71	**Develop Performance and Cost Assessments that Limit Greenhouse**
71.1	U.S. Energy Technology Assessment
71.2	DOE Contribution to IPCC Energy Technology Assessment for INC
71.3	Complete IPCC International Energy Technology Assessment Report
72	**Help to Streamline Energy Facility Siting**
72.1	Work With CEQ to Establish, Organize, and Conduct Task Force
72.2	Establish Internal DOE Working Group on Energy Facility Siting
72.3	Conduct Siting Studies
72.4	Support Preparation of Task Reports and Federal Action Plan
72.5	Support Initiation of Federal Action Plan
73	**Develop Required Guidelines for Preparing Impacts of Proposed Re**
73.1	Prepare DOE Report on How Energy Impact Analyses Should Be Don
73.2	Form Interagency Task Force
73.3	Interagency Draft Report Prepared
73.4	Administration Approval of Report
73.5	Prepare DOE/OMB Tracking System to Implement Analysis Guidance
76	**Establish Federal Research and Development Priorities**
76.1	Phase I: Produce Preliminary List of Technical Objectives for FY 199
76.2	Phase II: Refine the Initial List of Technical Objectives for FY 1994
76.3	Phase III: Publish a Final Report of Technical Objectives of FY 1994
76.4	Phase IV: Establish a Follow-Up Plan of Program Planning and Budg



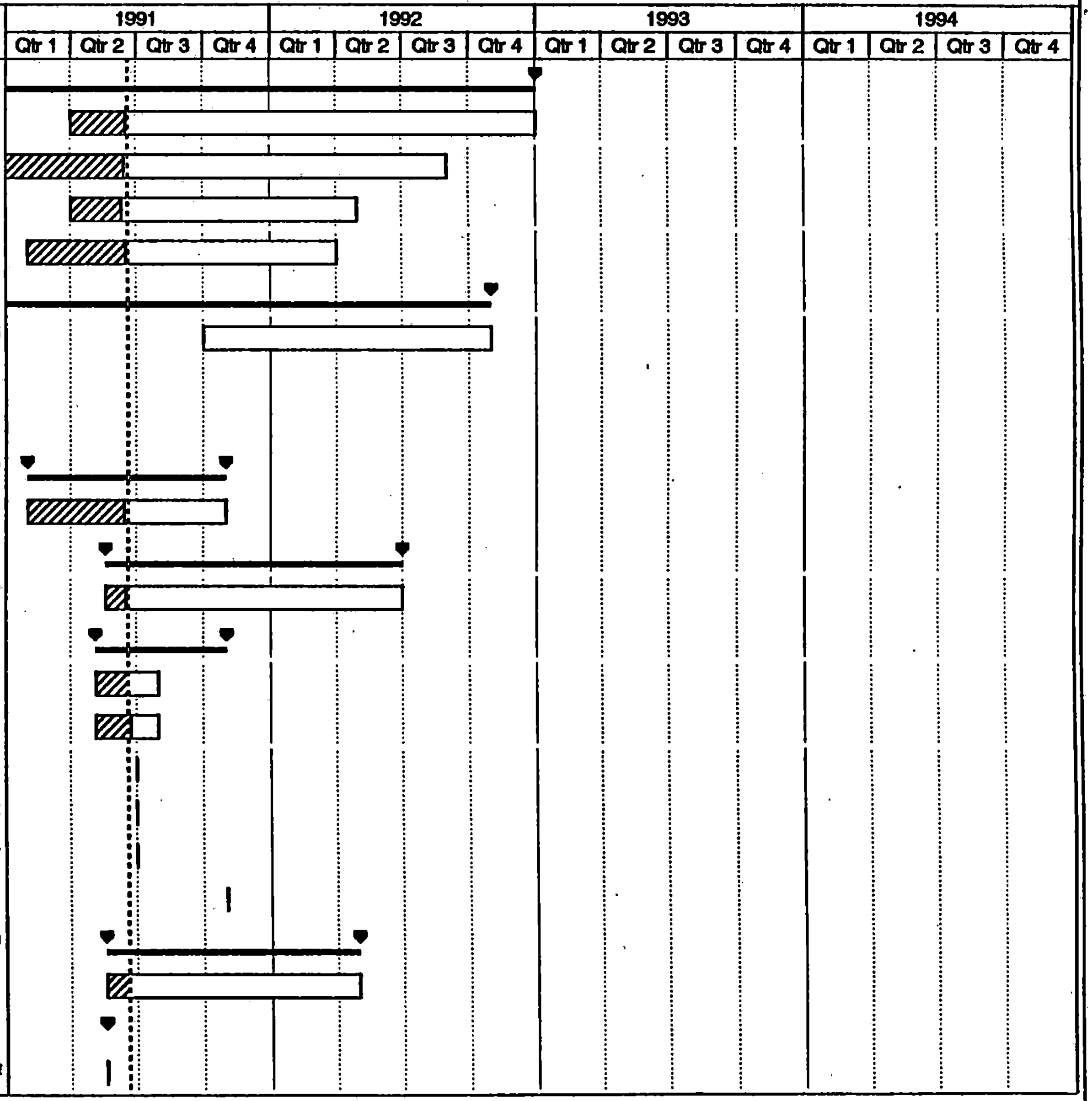
Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative Ac s Tracking System

Status as of June 18, 1991

No.	Administrative Action
77	**Maintain U.S. Preeminence and Promote Excellence in Fundamental**
77.1	Increase Fed. Support for Mathematics and Science Ed.
77.2	Improve Public Science Literacy, Especially in Regard to Energy
77.3	Strengthen Small Science Research
77.4	Maintain User Facilities
78	**Pursue R&D on Nuclear Fusion Power**
78.1	Develop Both Magnetic and Internal Approaches Seperately Until a Cl
78.2	Continue Collaboration and Cost Sharing
78.3	Prove Technical and Econ. Credibility of Fusion as a Power Source
81	**Pursue International Collaboration for High-Cost, Long-Term Resear**
81.1	Establish Procedures to Encourage Intl. Invlmnt. and Cost Sharing.
82	**Encourage Cost-Sharing Consortia**
82.1	Dvlop. Action Plans for Encouraging Cost-Sharing Consortia With OMI
83	**Improve Federal Technology Transfer**
83.1	Issue Guidance
83.2	Continue Eval. of Conflict-of-Interest Laws and Policies
83.3	Permit Fed. Govt. Agencies to Obtn Cpyrghts. for Comp. Sftwr. Dvlpd.
83.4	Extend Nat. Coop. Research Act (NCRA) Protection to Joint Prod. Act
83.5	Recommend Revisions to Fed. Govmnt. Procurements Regulations ar
83.6	Council on Competitiveness Report.
84	**Establish Award Program for Innovations that Reduces U.S. Oil Vuln**
84.1	Evaluation and Selection of Award Winners
85	**Improve the National Infrastructure for Technology Transfer**
85.1	Conduct the Review of the National Technology Transfer Infrastructur



Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ Progress ▨ Summary

NES Administrative A s Tracking System

Status as of June 18, 1991

No.	Administrative Action	1991				1992				1993				1994			
		Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
86	**Unify the Federal Export Promotion Effort**		▼														
86.1	Prepare a Proposal for Expndng the TPCC Chrter for Unifying the Fed		▨														

Project: NES Administrative Actions
Date: 6/18/91

Schedule ☐ **Progress** ▨ **Summary** ▼▁▁▁▼

GM

FROM
JAMES D. JOHNSTON
VICE PRESIDENT
INDUSTRY-GOVERNMENT RELATIONS

THE CHIEF of STAFF
has seen

Post-it™ brand fax transmittal memo 7671 # of pages ▸

To Ed Rogers	From Jim Johnston
Co.	Co. General Motors
Dept.	Phone # 202/775-5090
Fax #	Fax # 202/775-5035

Mr. Ed Rogers
Executive Assistant to
the Chief of Staff
The White House

National Academy of Science's Study of Fuel Economy

As I mentioned, we believe the NAS study of the technological feasibility and economic practicability of further motor vehicle fuel economy improvements is of increasing importance. Prior to DOT's contracting the NAS study, our trade association, the Motor Vehicle Manufacturers Association, commission two studies, one with SRI and other with Charles River Associates. This was done because of the lack of serious studies of the subject.

These studies are now complete, and we are planning to make them available to the NAS study committee for background. (Since they are relevant to the NAS study, we think it is appropriate to do so.)

o The SRI report concludes that the passenger car fleet could achieve increases of 0.7 mpg and 1.3 mpg in 1995 and 2001 (over a 1990 baseline), based on a 4-year payback, and 0.7 mpg and 2.6 mpg in 1995 and 2001, based on a 10-year payback. (These projections are based on data SRI received from Ford, GM, Honda and Chrysler.) For light duty trucks, the fleet could achieve increases of 0.7 mpg and 1.1 mpg, based on a 4-year payback, and 0.7 mpg and 1.6 mpg, based on a 10-year payback.

  The analysis is based on a calculation of cost-effectiveness which compared economic benefits (fuel cost savings exceeding the cost of a technology) to the retail cost of implementing various technologies.

o The Charles River study concludes that, as an energy conservation measure, higher CAFE is probably quite costly and is definitely very risky. A 40 percent increase in CAFE standards could save 300,000 barrels per day of oil by 2001, at a most likely cost of $32 per barrel saved, above and beyond the price of the oil per barrel.

  It also finds that, if global warming is the concern driving energy conservation initiatives, then by far the most cost-effective policy measure is imposing a carbon fee. A modest carbon fee — equivalent to 5 cents per gallon of gasoline — could achieve the same CO2 reductions as the Bryan bill.

In the interest of keeping the Governor well informed on this issue, we wanted to advise him of these plans. Of course, we would welcome any comments or suggestions.

Jim Johnston

JDJ:cba
7/2/91

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WASHINGTON, D.C. 20036
GENERAL MOTORS BLDG.
DETROIT, MICHIGAN 48202

THE WHITE HOUSE
WASHINGTON

Date: July 9, 1991

FOR: GOVERNOR SUNUNU

FROM: **ED ROGERS**

☐ Action

☐ Your Comment

☐ Let's Talk

X☒X FYI

Copy to Porter as well.

Final Report • July 1991
SRI Project 1955

POTENTIAL FOR IMPROVED FUEL ECONOMY IN PASSENGER CARS AND LIGHT TRUCKS

Prepared for:

MOTOR VEHICLE MANUFACTURERS ASSOCIATION
Detroit, Michigan

Prepared by:

Larry M. Rinek
Pamela J. Olson
Norman Stoller
Global Automotive Practice

THE CHIEF of STAFF
has seen

"In the event MVMA intends to distribute outside of its own organization any report issued under their project, such report should be used in its entirety, unless any proposed summary or abridgment of the report has been first approved by SRI."

Ref. MVMA Agreement Number SRI 9107-C1124
Section VII (Publications)

CONTENTS

ILLUSTRATIONS

TABLES

I EXECUTIVE SUMMARY

INTRODUCTION

The Motor Vehicle Manufacturers Association (MVMA) retained SRI International (SRI) to perform an independent analysis of the potential for fuel economy (FE) improvements and associated costs for cars and light-duty trucks (LDTs). SRI was pleased to be the consultant chosen to assist MVMA.

The objective of the project effort was to examine the potential FE [miles per gallon (mpg)] gains achievable by the participating MVMA member (GM, Ford, Chrysler, Honda) vehicle fleets for model year (MY) 1995 and MY 2001, combining domestic and imported vehicles. As is done when the Secretary of Transportation determines maximum feasible average fuel economy, SRI considered technological feasibility, economic practicability, and the effect of other federal motor vehicle standards on fuel economy.

To determine the potential FE gains for a free market environment, SRI evaluated the fuel economy gains for various technologies and incorporated those technology improvements (TIs) that (1) would not cause shifts in consumer choice, produce size, driveability, or performance other than those already incorporated in the manufacturer's product plans; (2) would not directly result in loss of U.S. employment in the automotive industry or among its suppliers; and (3) considered the effects of other state and federal standards (e.g., safety and environmental regulations). The effects of fuel prices were also considered and the cost-effectiveness for the technologies were analyzed with two payback periods: 4 years and 10 years.

This study is new and different from other fuel economy projection studies in that SRI was granted access to proprietary information. Product plans from GM, Ford, Chrysler, and Honda on a platform-by-platform basis—including power train and body roll-out plans, new vehicle programs, plant capacity levels, and cost data—provided SRI the ability to conduct a study that would most accurately describe the industry's fuel economy capabilities through the year 2001.

SRI first formed a project team of professionals with extensive experience and knowledge of the automotive industries. The team assessed information from a comprehensive set of global sources. These sources included published data, in-depth interviews with personnel of key organizations in the industry, interviews with outsiders familiar with FE issues, and telephone interviews that provided further supplemental information. Using this information and the findings of its exhaustive personal computer-based analyses, the SRI team prepared forecasts of industry capability for improving fuel economy through cost-effective technologies—that is, technologies for which dollar fuel savings exceed initial retail costs.

In essence, SRI's FE forecast procedure entailed the development of baseline 1990 values on a platform-level basis, followed by addition of FE gains for 1995 and 2001 (TI by TI) that were either planned by the companies or met certain conditions (e.g., market available, cost-effective). Fleet results were then aggregated with sales volume weighting. (See Section II and Appendix A for more details on methodology.)

FINDINGS AND CONCLUSIONS

The findings and conclusions of SRI's research are summarized below for each of the key categories investigated; the forecast of maximum feasible/practicable FE and the economic analysis of TIs. The main text provides a detailed review of each of these main issues, and Appendixes A through F provide detailed backup data.

Maximum Feasible/Practicable Fuel Economy

SRI's evaluation of the potential FE gain achievable under "product plan plus" (e.g., product plans enhanced by FE-gaining TIs) conditions, such as increased use of market-available and cost-effective TIs, resulted in several key findings. These findings are summarized below:

- Projected FE gains for both passenger car and LDT fleets are fairly conservative and would be slightly better in the absence of the safety and emissions regulatory requirements scheduled for the next several years.
- SRI forecast a net fleet gain for passenger cars of 0.7 mpg for MY 1995 and 1.3 mpg for MY 2001 as compared with the MY 1990 baseline, given 4-year payback TIs. Depending on the manufacturer, a range of opportunities in FE gain will be above or below these average miles-per-gallon forecasts.
- The car fleet gain with a 10-year payback basis is forecast at 0.7 mpg for MY 1995 and 2.6 mpg for MY 2001 as compared with the MY 1990 baseline.
- Results of the FE analysis for cars by EPA size class show that most of the future fleet gains in miles per gallon will be attributed to improvements in compact and large cars
- Results of the LDT analysis forecast fleet gains of 0.7 mpg for MY 1995 and 1.1 mpg for MY 2001 as compared with the MY 1990 baseline, given 4-yr payback TIs.
- The LDT fleet gain with a 10-year payback basis is forecast at 0.7 mpg for MY 1995 and 1.6 mpg for MY 2001 as compared with the MY 1990 baseline.
- Results of the LDT analysis by EPA class suggest that most of the fleet FE gains will be achieved by improvements in 4WD large pickups, 2WD small pickups, and 4WD small pickups.
- A review of technology penetration changes suggest that forthcoming upgrades to fuel delivery systems, valve trains, and automatic transmissions (ATs) will be responsible for much of the fleet FE gain.

Economic Analysis

SRI's analysis of economic aspects of the FE TIs produced some interesting findings. These findings are as follows:

- Relatively few TIs demonstrated cost-effectiveness (projected dollar savings in fuel exceeding initial retail cost).

- The list of cost-effective TIs increased somewhat as the payback period was extended from 4 to 10 years and with extension of vehicle purchase from MY 1995 to MY 2001, but the majority of the TIs remained noneconomic.
- Analysis of fuel price sensitivity indicated that few TIs would be reclassified in terms of cost-effectiveness by modest variations (+30¢/gallon, -20¢/gallon) in gasoline price versus baseline prices. In other words, the economic attractiveness of most TI candidates is not sensitive to modest fuel price variations.
- A review of industry-level resource aspects revealed that substantial funding and engineering resource (e.g., trained engineers, test facilities) limitations are applicable to FE enhancement, particularly given all of the other priority items already on the agenda (e.g., the 1990 Clean Air Act, safety regulations, competitive pressure, and so forth).

II INTRODUCTION

BACKGROUND

Since the early 1970s, automotive manufacturers have achieved significant improvements in fuel economy. The corporate average fuel economy (CAFE) for the combined domestic and imported passenger car fleet has risen from 14.2 mpg in 1974 to an estimated 28.2 mpg in 1991, a 98.6% improvement. Light trucks have also shown significant improvements throughout the 1980s. The combined domestic and imported light-truck CAFE improved from an average of 18.2 mpg in 1979 to 21.2 mpg in 1991, a 16.5% improvement. Tables 1, 2, 3, and 4 show the historical CAFE improvement by manufacturer and total fleet for passenger cars and light trucks. Figure 1 graphically presents the historical fuel economy (FE) improvements for new passenger cars, and Figure 2 illustrates the improvements for light trucks. Weight reduction and technological improvements (TIs) in these vehicles contributed to major gains in fuel economy during the mid-1970s to early 1980s. Marginal improvements in FE were achieved during the late 1980s, an era in which gasoline prices declined and fuel economy decreased in importance as a motivator for a consumer to purchase a car. Consumers' demand therefore shifted to larger vehicles, thus reducing CAFE levels.

Recently, pressure has been applied to the United States Congress for various reasons (such as U.S. dependence on foreign oil) to dramatically increase mandatory fuel economy standards. In particular, the United States Senate in 1990 considered legislation calling for a 40% improvement in CAFE by 2001 [S.1224 sponsored by Senator Richard Bryan (D-Nevada)]. Although S.1224 was withdrawn from the Senate floor in late September 1990, similar legislation is moving forward in 1991.

The issue of enhanced FE is inherently challenging to the vehicle builder because of the technical complexity, conflicting regulations, and severe constraints imposed by external factors (such as fuel prices and market forces). A multitude of known means have been and can be used to achieve better FE although they are not always cost-effective (i.e., the cost to the consumer is higher than the benefit). In the body/chassis area, for example, substantial progress has been made and improvements such as reduction of size, aerodynamic drag, rolling resistance, and weight continue to be made. Similarly, in the power train, many efficiency enhancements have been obtained through developments in the engines [such as advanced multivalve dual overhead cams (DOHC) cylinders heads and substitution of aluminum for iron castings] and transmissions (such as using electronic controls, switching from 3 or 4 to 5 speeds, using lockup torque converters). All of the different approaches vary in terms of cost-effectiveness and suitability for diffusion through the fleets of tomorrow. Many approaches are not cost-effective at current fuel prices.

Table 1
MANUFACTURER'S NEW CAR CORPORATE AVERAGE FUEL ECONOMY RATING: CITY/HIGHWAY (Miles per Gallon)

	Actual Sales													Preliminary Sales		
Manufacturer	1974	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Domestic Fleets															
America Motors	16.3	18.6	20.7	22.3	23.1	25.0	24.5	*	–	–	–	–	–	–	–
Chrysler	13.9	18.4	20.5	22.3	26.8	27.6	26.9	27.8	27.8	27.8	27.5	28.5	28.0	27.1	27.5
Ford Motor	14.2	18.4	19.2	22.9	24.1	25.0	24.3	25.6	26.6	27.0	26.9	26.6	26.6	26.4	27.6
General Motors	12.1	19.0	19.1	22.6	23.8	24.6	24.0	24.9	25.8	26.6	26.9	27.6	27.2	27.1	27.0
Import Fleets															
Alfa Romeo	–	21.4	20.7	22.4	23.1	25.0	25.8	27.5	27.7	27.9	25.5	25.7	26.9	30.1	25.2
AMSC-Renault	–	30.4	30.3	34.3	30.2	32.9	32.0	33.2	28.6	26.5	33.0	–	–	–	–
BMW	19.5	19.7	20.1	26.7	27.3	26.9	26.2	28.0	26.4	25.7	24.9	21.7	22.2	22.2	23.2
Chrysler	–	30.6	32.3	33.6	32.9	33.6	34.5	36.2	36.2	36.8	33.4	30.7	30.3	30.5	28.4
Fiat-Lancia	–	21.7	26.4	27.4	28.4	26.1	13.2	–	–	–	–	–	–	–	–
Ford Motor	–	37.3	32.1	30.7	35.2	34.9	35.4	35.6	25.2	24.3	24.2	35.9	31.5	32.3	33.3
Fuji (Subaru)	25.7	29.4	29.0	28.7	32.0	32.0	33.0	33.3	32.6	31.9	31.0	31.9	32.5	27.8	28.8
General Motors	–	26.9	29.0	–	–	–	–	–	47.9	41.2	39.0	37.6	37.1	32.1	31.6
Honda	31.1	33.7	29.0	30.3	31.6	33.9	36.0	35.8	34.5	33.3	33.2	32.1	31.6	30.8	30.4
Hyundai	–	–	–	–	–	–	–	–	–	35.1	34.8	34.5	33.4	33.3	33.6
Isuzu	–	–	–	–	35.6	38.1	31.4	29.2	34.2	35.5	38.6	34.9	35.8	33.2	34.2
Mercedez-Benz	15.3	19.2	20.5	24.6	26.3	26.6	27.2	26.2	23.6	21.3	22.3	21.3	21.4	21.4	22.4
MG-TR-Jaguar	21.3	21.1	21.2	22.2	19.0	19.0	19.0	19.4	19.3	19.0	19.3	22.1	20.4	–	–
Mitsubishi	–	–	–	–	–	33.6	30.8	31.6	31.9	31.5	31.7	81.2	31.0	30.0	30.3
Nissan (Datsun)	24.0	26.8	26.8	32.2	31.4	31.2	33.4	32.5	30.1	30.3	29.7	30.8	30.4	28.4	28.8
NUMMI (GM-Toyota)	–	–	–	–	–	–	–	–	35.7	36.4	†	†	†	–	–
Peugeot	19.0	24.8	23.8	26.1	26.7	26.0	25.6	25.0	25.2	24.8	24.1	23.6	25.5	25.1	26.0
Saab	19.6	22.7	21.7	24.3	24.1	24.6	26.6	26.0	26.4	26.3	26.2	26.5	26.6	–	–
Suzuki	–	–	–	–	–	–	–	–	58.7	52.5	50.4	50.3	36.9	47.4	43.3
Toyota	22.5	26.6	24.0	28.3	31.8	30.9	33.3	33.5	33.5	32.7	33.4	33.0	32.1	30.6	30.5
Toyo Kogyo (Mazda)	13.6	35.5	25.6	26.8	31.9	29.8	29.4	30.6	30.3	29.7	29.6	28.7	29.8	30.5	29.8
Volvo	19.4	21.2	21.0	22.3	22.9	25.0	26.5	27.0	27.2	26.8	26.4	26.0	25.0	25.2	25.2
VW-Audi-Porsche	25.9	27.2	28.6	32.3	35.2	33.4	30.7	29.1	30.5‡	29.8	30.1	30.5	30.4	29.0	29.6
Yugo	–	–	–	–	–	–	–	–	–	32.1	33.7	33.8	33.8	34.0	34.6

Notes: The 1974 figures are estimated, based on 1972 FTP Certification figures. The GM, Ford, and Chrysler averages reflect the full-sales inclusion of captive imports in 1974-77, their partial inclusion in 1978-79 and total exclusion in 1980. Beginning with MY 1980, figures reflect CAFE adjustments resulting from changes in test procedure (Federal Register, July 1, 1985).

* NHTSA determined that AMC was no longer a "domestic" producer because it did not meet the domestic content requirements of P.L.94-163.

† Beginning in 1987, vehicles are counted as part of Toyota and GM import fleets.

‡ Beginning with MY 1985, Porsche is not included in VW fleet.

Sources: 1974-77 data: U.S. Environmental Protection Agency (Murrell, Foster, Bristor), "Passenger Car And Light Truck Fuel Economy Trends Through 1980," SAE No. 80053. 1978-1991 data: U.S. Department of Transportation, February 1, 1991

Table 2
50-STATE CORPORATE AVERAGE FUEL ECONOMY FOR NEW CARS
(City/Highway Miles per Gallon)

Model Year	Federal Standard*	Total Fleet
1974	None	14.2
1975	None	15.8
1976	None	17.5
1977	None	18.3
1978	18.0	19.9
1979	19.0	20.3
1980†	20.0	24.3
1981	22.0	25.9
1982	24.0	26.6
1983	26.0	26.4
1984	27.0	26.9
1985	27.5	27.6
1986	26.0‡	28.2
1987	26.0§	28.5
1988	26.0§	28.8
1989 (preliminary)	26.5**	28.3
1990 (preliminary)	27.5††	28.1
1991 (preliminary)	27.5	28.2

Note: Figures for 1989, 1990, and 1991 are preliminary estimates.

* Alternative standards may be set for certain low-volume manufacturers for example Maserati, Lamborhini, London Coach). (*Federal Register*, April 4, 1990)

† After 1979, domestic fleet does not include any domestic sponsored imports.

‡ NHTSA revised 1986 standard on October 4, 1985.

§ NHTSA revised 1987 standard on October 6, 1986.

** NHTSA set standard of 26.5 mpg on April 5, 1988.

†† NHTSA retained standard of 27.5 mpg on May 22, 1989.

Source: U.S. Department of Transportation, February 1, 1991.

Table 3
NEW LIGHT-TRUCK FUEL ECONOMY/COMBINED 2WD AND 4WD FLEETS
(Sales-Weighted City/Highway Miles per Gallon)

Model Year	Federal Standard	Total Fleet
1979*	†	18.2
1980	†	18.5
1981	†	20.1
1982	17.5	20.5
1983	19.0	20.7
1984	20.0	20.6
1985	19.5	20.7
1986	20.0	21.5
1987	20.5	21.7
1988	20.5	21.3
1989	20.5	20.9
1990	20.0	20.8
1991	20.2	21.2

* GVWR 0-8000lb

† No combined 2WD/4WD standard

Source: U.S. Department of Transportation, February 1, 1991

Table 4
CHARACTERISTICS OF U.S. AUTOMOBILES

	1975	1990	Change
Total passenger car fleet average			
City/Highway mpg	15.8	27.8	+ 12
Weight (lb)	4058	3171	–887
Displacement (in.^{3})	288	164	–124
Fuel injection (%)	5.1	96.0	+ 90.9
Manual transmission (%)	19.9	23.1	+ 3.2
Front-wheel drive (%)	6.5	81.5	+ 75
Total light-truck fleet average			
City/Highway mpg	13.7	21.0	+ 7.3
Weight (lb)	4072	3952	–120
Displacement (in.^{3})	311	233	– 78
Fuel injection (%)	0.1	95.6	+ 95.5
Manual transmission (%)	37.0	29.0	– 8
Front-wheel drive (%)	—	13.6	+ 13.6

Source: EPA, Murrell & Heavenrich, "Light-Duty Automobile Technology and Fuel Economy Trends Through 1990"

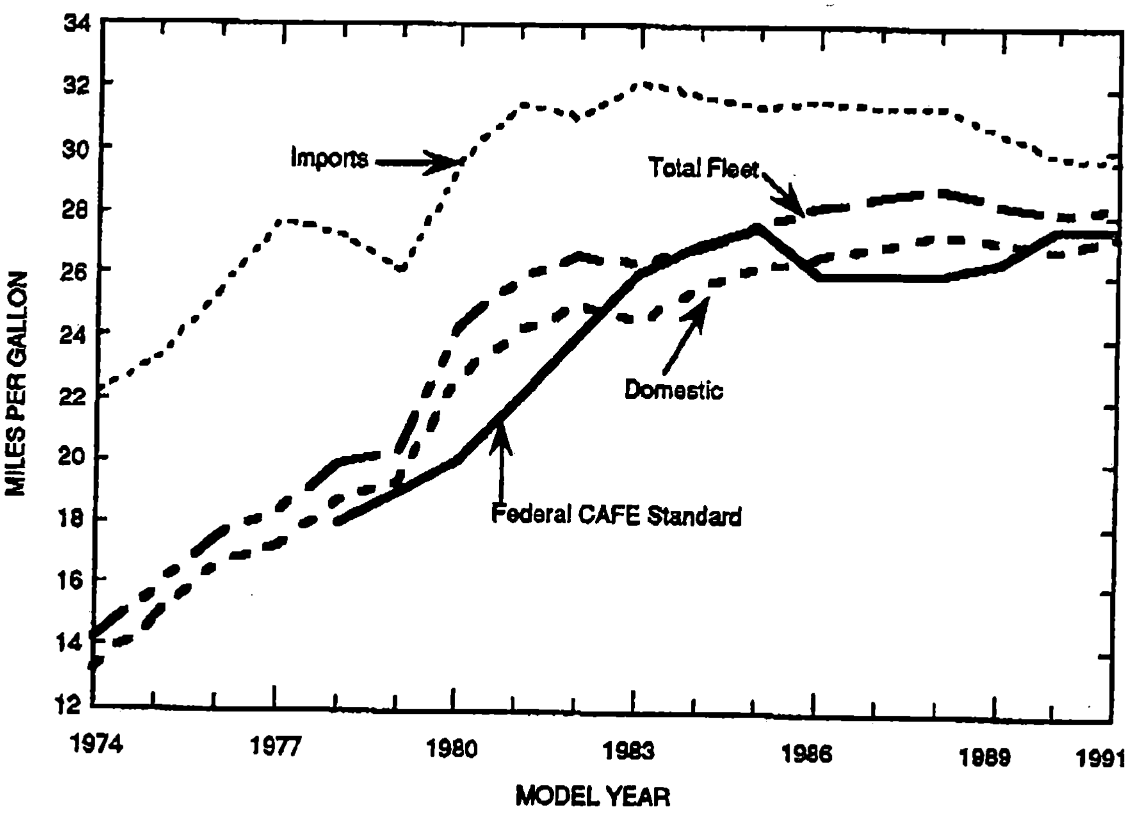


FIGURE 1 NEW PASSENGER CAR FUEL ECONOMY, 1974—1991

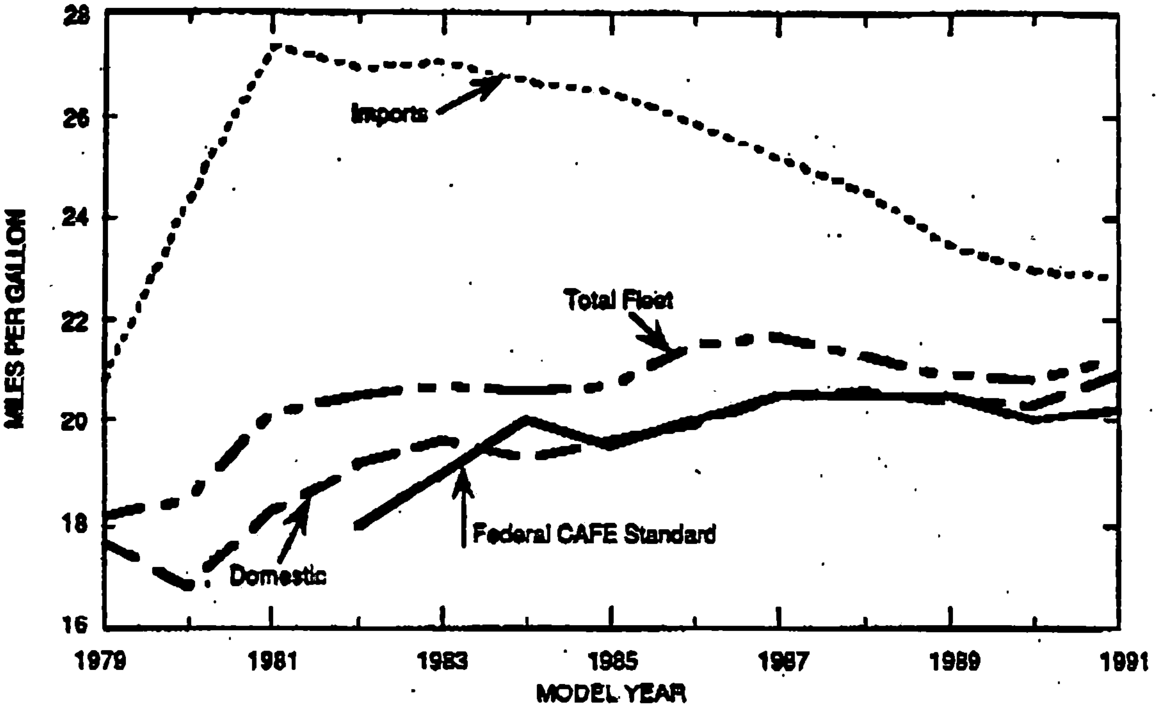


FIGURE 2 NEW LIGHT-TRUCK FUEL ECONOMY, 1979—1991

The analysis of vehicle FE is complex and often controversial. The Motor Vehicle Manufacturers Association (MVMA), based in Detroit Michigan, therefore sought an independent study to assess the technological feasibility and economic practicability of increased fuel economy. SRI International (SRI) is pleased that MVMA chose SRI International's (SRI) Global Automotive Practice to undertake this important and challenging assignment.

OBJECTIVES AND SCOPE

In accordance with MVMA Agreement Number SRI 9107-C1124 (22 January 1991), SRI initiated the project with the primary objective of forecasting the industry's capability to improve future FE of gasoline- and diesel-powered cars and light trucks. SRI was retained to "conduct a study that will contribute to the quality of public debate about vehicle fuel economy legislative and regulatory policy," as stated on page 1 of the MVMA agreement. SRI was asked to compare the 1990 baseline of Chrysler, Ford, GM, and Honda as to the effects of reaching the maximum feasible/practical level to determine the differences in fuel economy and economic impacts (e.g., retail product costs, investments, lead time, etc.).

The scope of SRI's study considered economic practicability, technological feasibility, the effects of state and federal regulatory requirements, and customer acceptance of potential fuel economy measures. The scope also encompassed estimation of fuel economy benefit and cost of individual technologies based upon the best available data and engineering estimates applying sound engineering principles and substantiated by applicable technical literature, taking into account lead time, product variability, manufacturing limitations, and other production and customer considerations.

METHOD OF APPROACH

The project began with a kick-off meeting held in Detroit on January 4, 1991. (See Appendix B for identification of the project team and their professional responsibilities.) The SRI team initiated the project effort with a manual and computer search of global data publications. The team then reviewed this information and published data that MVMA and its members made available to SRI during the January 4 meeting. In late January, the team began the U.S. field investigation program, conducting intense interviews (i.e., day-long work sessions with experts in technology, economics, etc.) with vehicle OEMs, component systems suppliers, and other sources. Following this U.S. investigation, team members conducted offshore interviews with relevant sources in Japan and Europe. To supplement the above interviews, SRI staff members conducted numerous telephone discussions. (See Appendix C for a complete list of organizations that SRI visited.)

As background, SRI also received extensive proprietary information from the participating MVMA manufacturers (GM, Ford, Chrysler and Honda). This information includes descriptions of a 1990 baseline model year (MY), changes, new technology, investments, costs, and other information necessary to define FE-related improvements targeted for MY 1995 and MY 2001.

The SRI team established the 1990 baseline for the participating manufacturers' fleet as an initial step in the data reduction process. The team repeatedly met and agreed on various ground rules about how to handle platform changes, criteria for determining which TIs satisfied the study conditions, probable gains for the TIs, and how to correctly and consistently perform the electronic spreadsheet work. In parallel, SRI experts performed the economic analysis; however, the final determination of the TI benefits (fuel savings stream) depended on the final mpg results of the forecast analysis. Various team members cross-checked the mpg and economic analysis to ensure their accuracy.

SRI began with an examination of manufacturers' product plans and then increased, if possible, the use of market-available, cost-effective technologies for MY 1995 and MY 2001. SRI then estimated only maximum feasible/practicable FE potential for each manufacturer's platforms and fleet. The estimates reflected the range of uncertainties and opportunities surrounding the benefits of technology, application rates for such technology, and the effects of factors outside the manufacturer's control. For gasoline and diesel-powered passenger car and light-truck fleets, SRI established a sales-weighted, harmonically averaged FE level for the manufacturers as a whole (combining both imported and domestic fleets), in MY 1995 and MY 2001. Data were also aggregated by market segments as defined by EPA size classes for passenger cars and for light trucks. MVMA wanted SRI's analysis to represent market-driven CAFE improvements that would be cost-effective based on the projected fuel prices through this decade. Thus, SRI did not consider actions that would either:

- Directly result in a net loss of U.S. employment in the automotive industry or among its suppliers (e.g., re-sourcing products, product deletion/restriction, etc.)
- Or cause shifts in consumer choice, product size, driveability, or performance other than those already incorporated in the manufacturer's product plans.

SRI took into account the potential influences of non-MVMA member automakers and components sources in the future market. Most of the data sources listed in Appendix C are not participating members of MVMA.

In conducting this study, SRI also considered the following:

- Effects of state and federal requirements in the areas of safety, emissions, chlorofluorocarbon (CFC) phase-out, damageability, and noise. Such requirements frequently lead to weight increases that reduce FE.
- Assessments of potential FE benefit of technology based on engineering evaluation, published material, data from outside MVMA membership, and a study of existing products. Note that the engineering evaluation did not include independent laboratory tests at SRI, but it did involve the collective judgment of a group of members of the Society of Automotive Engineers (SAE) on the SRI project team.
- Cost-effective applications of technology for two scenarios with different payback periods based on fuel-price trends for each technology and a 10% discount rate for both scenarios. Both scenarios are based on the:
  - Present value of (PV) fuel cost savings to the customer
  - Technology costs at the retail level
  - Market acceptability (reasonable, accepted consumer perception of use, serviceability, cost and benefit).

  Scenario 1 uses only technologies that achieve payback in fuel savings within 4 years (the assumed ownership of the original buyer). Scenario 2 allows technologies to be used if payback is achieved within 10 years (approximate lifetime of the vehicle). The scenarios were used to establish the range of potential maximum feasible fuel economies for the industry.
- Effects of future fuel prices on and availability of technology applications based upon SRI's oil price forecast.
- Practicable rates of technology diffusion, considering product life cycles, individual manufacturer lead times, capital constraints, and sourcing capability.
- Constraints on manufacturers' ability to satisfy market needs for utility, size, mix, convenience, performance, safety, and comfort.

Most of the industry-provided data were highly proprietary, and SRI treated all of these data with strict confidence and utmost security. Only designated SRI project team members had access to the data, and all data was kept in a limited access secure office. Upon completion of the project all proprietary material will be shredded or returned to the providers.

REPORT ORGANIZATION

The report consists of four sections and six appendixes. The prior executive summary presents highlights of the project findings and the SRI team's conclusions. Following this introduction are the two key sections containing the significant elements of the research. The fuel economy forecast of Section III gives the reader a basis for understanding what improvements are feasible/practicable in reducing fuel consumption, how these results vary by type of vehicle and year of purchase (MY 1995 or MY 2001), and by economic scenario (4- or 10-year payback of costs). Section IV provides details regarding the economic analysis, particularly the benefits versus costs for the various TIs. Finally, the appendixes supplement the main report with information about details on SRI's methodologies and computations in Appendix A, the SRI project team in Appendix B, a list of field contacts in Appendix C, background of SRI's gasoline price forecast in Appendix D, projections of miles that vehicles travel each year in Appendix E, and fuel price-sensitivity data in Appendix F. For reader convenience, a glossary is provided at the end of the report.

III FORECAST OF MAXIMUM FEASIBLE/PRACTICABLE FUEL ECONOMY

INTRODUCTION

The major findings of this study are the FE projections for the participating manufacturers' domestic and import fleets expected to be sold in the United States in MY 1995 and MY 2001 based on future product plans. Note that passenger cars are separated from light-duty trucks (LDTs) throughout the presentation of results of the miles-per-gallon discussion. Cars and LDTs differ considerably from a FE point of view. For example, LDTs must meet certain utility and load-carrying needs not required of passenger cars, thus driving up vehicle weight and compromising aerodynamics. The need for larger and higher torque power trains in LDTs also limits the prospects for FE gains. Moreover, certain passenger car TIs—for example, overhead cams (OHC)—are less acceptable to LDT consumers.

DESCRIPTION OF MAJOR FUEL ECONOMY TECHNOLOGY IMPROVEMENTS

SRI's description and remarks on technology improvements sets the stage for the subsequent presentation of miles-per-gallon results. The major TIs are described below.

Compression Ratio Increase. A small increase (5-6%) in compression ratio can measurably improve FE (and power) with better thermal efficiency of the engine, but yet respect spark limits (not trigger detonation). This TI can be widely applied with small modifications to cylinder heads, electronic engine controls, and knock sensors but can retain existing fuel octane levels. FE gains are in the range of 1.3% (suboptimal basis) to 2.0% (optimal basis with performance neutral).

Decel Fuel Off. Fuel injectors are automatically shut off during deceleration, but are not applicable because reactivation can cause an increase in hydrocarbon (HC) emissions that would conflict with future emissions standards and consumer acceptance is questionable. FE gain is about 1%.

Special Lube Package. This special lube package uses reduced viscosity oils (such as synthetics) to replace regular mineral oils in the power trains, minimizing friction losses. Some R&D effort and supply enhancement (and EPA approval) are still necessary, but the package should be widely applicable by 1995. FE gain is about 0.3%.

Direct Acting Bucket. The DAB (e.g., solid lifter) approach to valve actuation by cams in lieu of hydraulic lash adjustors reduces pumping losses. The efficiency gain can be taken in FE (1.0% to 1.5%) or power or both, but these DAB valve trains can be noisy and need periodic mechanical adjustment. Consumer acceptance problems, therefore, block application.

Advanced Tires. Current rubber radial tires are highly developed and offer favorable rolling resistance. Advanced rubber radial or injection-molded polyurethane tire designs, however, can reduce rolling resistance by 10% to 15% from a 1990 baseline tire through reduction of flexing/hysteresis losses in the carcass and tread, yielding approximately a 1% FE gain. Applicability of these advanced tires will be widespread by 2001.

Aerodynamic Drag Reduction. Aerodynamic drag forces on the vehicle are proportional to the frontal area, the coefficient of drag (Cd), air density, and the square of air velocity. Drag reductions (on the order of 10%) can be addressed first with body shape and detail refinements (Cd reduction) and second with reductions in frontal area (more difficult). A 10% reduction in drag, which yields an FE gain of about 2.4%, can be generally accomplished at only major cycle points in body freshening and thus will be largely applied only after MY 1995. The industry is facing diminishing returns with this technology, and applicability to trucks is less feasible considering their large frontal area and open cargo areas.

Throttle Body Injection. Throttle body (single-point) electronic fuel injection (TBI) provides a substantial gain in FE (approximately 2.6%) and air/fuel metering control compared with carburetors. The superior emissions performance of multiport electronic fuel injection, however, means that TBI will be essentially superseded by MY 1995, and penetration will fall.

Roller Cam Follower. The roller cam follower (RCF), as implemented with either pushrod or overhead cam valve trains, reduces friction losses and improves FE (in the range of 1.0% to 2.3%) or power or both. The sliding contact with the cam is replaced by a hardened steel roller configuration. Applicability is widespread for cars and trucks.

Lockup Automatic Transmission. Instead of an open torque converter with continuous slippage losses, the lockup automatic transmission type is programmed to engage a clutch and become direct drive above certain ground speeds in gears 2/3/4, yielding FE gains (on the order of 1.7% to 2%) mainly in the highway mode of the test cycle. Lockup AT is widely applicable to cars and trucks.

Variable Valve Timing. Variable valve timing (VVT) can be implemented in various ways, but the strategy most relevant to this study is variation of intake valve phasing and possibly lift. Unlike fixed valve timing with inherent compromises in low-speed vs high-speed performance, the VVT allows both decent torque at low speeds and high power at high speed from downsized engines, which can translate to FE gains of about 2.6%. The high cost and low cost-effectiveness of VVT limits application to selected OHC engines.

Friction Reduction. In the power train, the chief friction losses appear first in the piston/bore vicinity and next in the numerous bearings. A long-term goal has been to reduce such parasitic losses; now after decades of effort, practical limitations loom. A redesign of pistons/rings and modification of bearings could, however, achieve a 10% reduction in friction from 1990 base levels, yielding an FE gain of 1.5% to 2.0%. This TI will be applicable mainly with power train cycle changes after MY 1995.

Ultra-Advanced Automatic Transmission. Application of proprietary technology to existing electronic lockup automatic transmissions can provide a 2% additional FE gain, making them very close to manual transmission efficiency. Ultra advanced ATs will be applicable mainly in selected platforms after MY 1995.

Weight Reduction. Using the 2:1 rule of thumb, every 10% reduction in vehicle weight yields a 5% FE gain. This would most likely be achieved primarily through materials substitutions and secondarily with downsizing of components. In this study, weight adjustments will mainly impact MY 1995 platforms.

Multiport/Sequential Fuel Injection. Modern multiport electronic fuel injection (MFI) with simultaneous actuation or sequential multiport electronic fuel injection (SFI) offers superior air/fuel metering, FE potential, power potential, and emissions performance, as compared to TBI and carburetion. Individual fuel injectors with electrical solenoid valves upstream of each intake valve are fed by pressurized fuel rails. FE gains are on the order of 1.5% to 2% over TBI. MFI/SFI will be widely applicable to all engines

4- and 5-Speed Automatic Transmissions. Compared with 3-speed automatics, the 4- and 5-speed transmissions (with or without lockup) allow engines to operate closer to top efficiency, with attendant FE gains (0.5% to 1.1%). Beyond 4 speeds, however, diminishing returns are realized. The 5-speed AT will appear mainly in certain cars (not trucks) after MY 1995.

Lean- Ultra-Lean Burn Engines. Instead of operating at stoichiometric (15:1) air fuel ratios, lean- ultra-lean burn engines operate at 18-22:1, often with a stratified charge system possibly with direct injection. The leaner burn approach saves fuel, but potential misfire and NO_X emissions control deficiencies precludes application of the engines for U.S. applications until a new catalyst system is developed. Available FE gain would be 6% to 10%.

Split Port Intake. The split port intake design allows variable intake tuning to optimize both low- and high-speed operation. A long runner with small diameter would always be open to one port, while the other port would be fed with a shorter/larger runner (including a butterfly valve) at higher speed only. A downsized engine would optimize FE gain. The gains available are in the range of 1.5% to 3%. This TI will be applied mainly after MY 1995 in U.S. engines.

Engine Weight Reduction. Substitution of cast aluminum for cast iron heads and blocks reduces engine weight and thus directly contributes an FE gain (1% or so for heads and 1.5% for blocks). Aluminum heads will be widely applied, blocks less so. Trucks will be less likely to use aluminum in engines.

Cylinder Reduction: V6 for V8 and I4 for V6. In theory, while holding displacement and peak horsepower constant, a reduction in cylinder count and moving parts count will reduce frictional losses and therefore provide an FE gain (approximately 1% with V6 for V8). In practice, these gains are offset by the higher lugging speeds inherent in engines with reduced cylinder counts. Consumer acceptance problems also make this TI not applicable.

Retuned Intake System. All intake systems are tuned, but some more optimally than others. Some redesigned intake manifolds/ports and valves would yield more efficiency or power (or both) that could be harnessed as a small FE gain (0.5%). This technology is already standard on many vehicles, and application of this technology is expanding.

Electronic Automatic Transmission. Use of electronic (in lieu of hydraulic) controls can better select shift points to yield a small FE gain (0.5%). Ultimately, one electronic control module would manage both engine and transmission control functions. This technology will be widely available by MY 1995.

2-Speed Accessory Drives. Single-speed drives of such accessories as power steering, water pumps, and alternators can drain excessive power at higher speeds. The 2-speed drive allows less power loss and some FE gain (0.7%). Poor cost-effectiveness, however, will limit the application of this TI.

Aluminum Heads. Besides the previously mentioned weight benefits of Al heads, combustion chamber designs in Al can better optimize power and emissions performance, yielding a small FE gain (approximately 0.5%). Al heads will be fairly common in passenger car engines in the 1990s.

Light Valve Trains. Substitution of titanium for steel valve train components improves high-speed stability and reduces inertial losses leading to a small FE gain (approximately 0.5%). Application will be more likely toward latter half of the decade.

Multivalve Heads. Addition of intake and exhaust valves (3V or 4V heads) improves breathing efficiency and power, particularly in the upper speed ranges. The chief FE gain (in the range of 0.8% to 1.3%) comes from use of downsized engines operating faster with equal power output. Low-speed torque aspects may suffer, however, thus limiting the utility of this TI for larger vehicles, such as LDTs. Use of multivalve heads will become more widespread on overhead cam engines in passenger cars.

Overhead Cam. The OHC (single or dual) for valve actuation (in lieu of pushrods) moves the cam to the top of each cylinder head, reducing the inertial losses in the valve train, improving high-speed operation, and allowing a more optimally shaped combustion chamber/port design. These benefits translate to power and FE gains (in the range of 1.1% to 2.5%) or both. The gain is about equal for SOHC or DOHC

Continuously Variable Transmissions. With the availability of a wider range of stepless drive ratios, the continuously variable transmission (CVT) in theory can more efficiently propel vehicles than can 3- or 4- or 5-speed automatic transmissions. In practice, the CVT is best suited for smaller passenger cars (not LDTs), and the actual FE gains are quite small (approximately 1% to 2% over 4-speed AT). Future electronic controls will help improve CVT performance.

Supercharged/Turbocharged Engines. Optimal redesigns of downsized gas engines with such forced induction systems can demonstrate potential FE gains up to 8% over comparable larger, naturally aspirated (NA) engines. In practice, however, the power gains are usually taken and the FE gain is not realized. These engines are not widely applied.

Electric Power Steering. The deletion of steering hydraulic power losses and replacement by electric motors can yield a noticeable FE gain (approximately 1.4%). Potentially high costs, however, limit the applicability of this TI.

FWD Layout. Setting aside weight differences, a conversion of RWD to FWD can produce a small FE gain (approximately 0.3% to 0.5%) by eliminating some gear set losses. The principle FWD benefit, however, is the repackaging opportunity that could lead to weight losses elsewhere in the body. Actual power train weights are not far apart (FWD vs RWD). High and steady penetration of FWD through the 1980s means that FE gain opportunities for FWD are minimal.

PASSENGER CAR FLEET

Table 5 presents SRI's FE fleet projections for cars, based on an aggregated bottom-up (platform-by-platform) analysis. These numbers represent a "product plan plus" view of potential miles-per-gallon results—that is, certain worthy TIs were added to existing product plans that are met in the contract conditions outlined in Section II. In preparing these projections, SRI used the following guidelines:

- Existing corporate future product plans for each platform were used in the analysis. These plans incorporate may TIs that manufacturers plan to include for reasons primarily other than for fuel savings. SRI's access to proprietary product plans enhances the creditability of the miles-per-gallon projections.
- SRI added TIs not already in the plan but that met contract conditions—for example, a lube package in MY 1995 and low-rolling resistance tires for most in MY 2001—but did not delete TIs from the plans (see Section IV).
- The 4- and 10-yr payback miles-per-gallon results for MY 1995 were the same, predominantly because 1995 capability is largely driven by increased use of FE improving technologies already in manufacturers' product plans. Further, some of those few technologies that become cost-effective on a 10-yr payback basis in 1995 are judged to be unacceptable to consumers (discussed in Section IV).

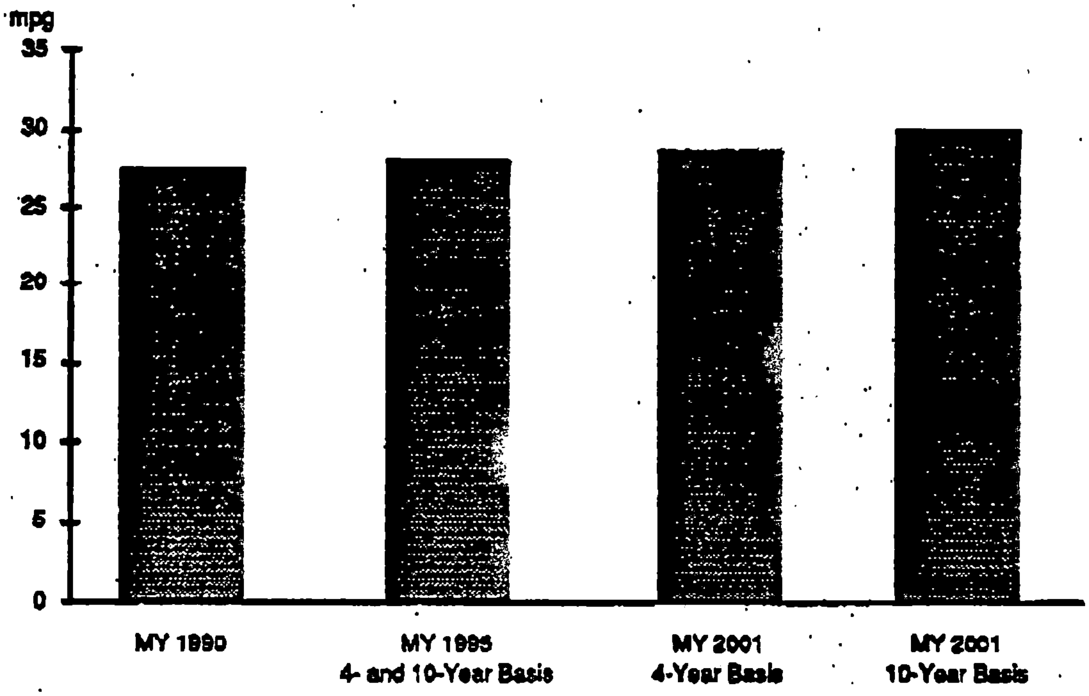
Table 5
U.S. PASSENGER CAR FLEET FUEL ECONOMY PROJECTIONS
(Domestic and Import)

	Fuel Economy* (mpg)		
Payback Period	MY 1990† Baseline‡	MY 1995† Projection	MY 2001† Projection
4 years	27.4	28.1	28.7
10 years	27.4	28.1	30.0

* Harmonically sales-weighted average across fleet.
† Federal Test Procedure Adjustment is not included.
‡ Based on actual data (as submitted to the EPA), unadjusted basis.
Source: SRI International, Ford, General Motors, Chrysler, Honda

Figure 3 summarizes the results of the miles-per-gallon analysis of the passenger car fleet in bar graph form. The key outcome of the analysis for passenger cars is a projected conservative future gain over 1990 baseline miles per gallon. Note, that SRI's calculated miles-per-gallon figures were unadjusted for special EPA credits. Each manufacturer is allowed a credit worth an additional 0.2-0.3 mpg for the change in the federal test procedure. For example, a federal test procedure adjustment would yield a MY1990 fleet FE of approximately 27.6 mpg.

Table 6 presents the results of the miles-per-gallon analysis of the passenger car fleet by EPA class (interior volume basis). These results show the considerable variance in miles per gallon across the range of car sizes. Generally speaking, as the car size and weight go up, the miles-per-gallon performance declines. The major energy loss incurred in driving any car is that required to overcome the inertia of the mass, followed by aerodynamic drag, and then rolling resistance.



SOURCE: SRI International

FIGURE 3 PASSENGER CAR FLEET FUEL ECONOMY OUTLOOK

Table 6
PASSENGER CAR FLEET FE PROJECTIONS, BY EPA CLASS

			MY 1995				MY 2001			
	MY 1990		4-yr Payback		10-yr Payback		4-yr Payback		10-yr Payback	
EPA Size Class	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction
2 seater	29.5	0.011	27.1	0.012	27.1	0.012	27.8	0.011	28.7	0.011
Subcompact	31.0	0.171	32.2	0.119	32.2	0.119	32.2	0.078	33.5	0.078
Compact	29.1	0.323	30.9	0.333	30.9	0.333	32.0	0.336	33.4	0.336
Midsize	26.6	0.294	27.0	0.239	27.0	0.239	27.5	0.309	28.9	0.309
Large	23.8	0.148	24.3	0.250	24.3	0.250	25.3	0.229	26.4	0.229
Station wagons										
Small	32.5	0.008	31.9	0.027	31.9	0.027	33.2	0.022	35.6	0.022
Mid size	25.4	0.024	26.3	0.020	26.3	0.020	26.6	0.015	28.3	0.015
Large	22.6	0.023	NA	0	NA	0	NA	0	NA	0
Fleet aggregate*	27.4	1.000	28.1	1.000	28.1	1.000	28.7	1.000	30.0	1.000

Note: Volume fractions for 1995 and 2001 are for SRI representative fleet and for 1990 the actual fleet. No data on minicompact EPA class.
*Harmonic mean volume-weighted, unadjusted
Source: SRI International

LIGHT-DUTY TRUCK FLEET

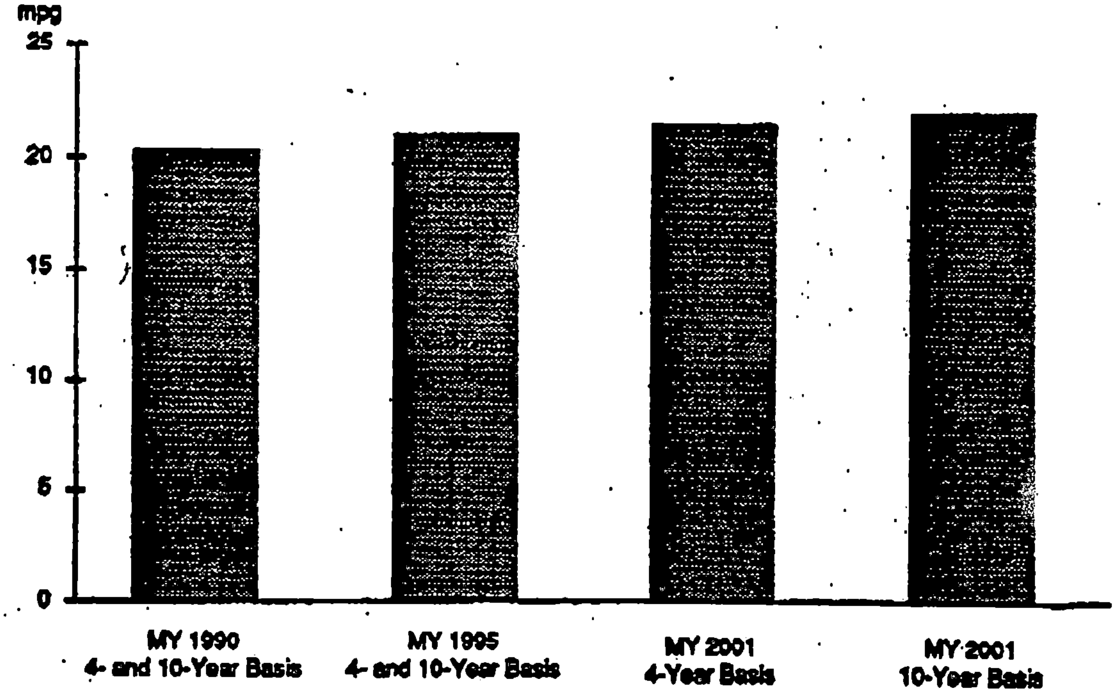
Table 7 and Figure 4 present SRI's LDT FE fleet projections. As for the passenger car fleet FE projections, SRI calculated the LDT FE projections on a "product plan plus" basis. Note that LDT fleets are based only on those of General Motors, Ford and Chrysler.

Table 7
U.S. LIGHT-DUTY TRUCK FLEET FUEL ECONOMY PROJECTIONS
(Domestic and Import)

Payback Period	Fuel Economy (mpg) MY 1990 Baseline†	MY 1995 Projection	MY 2001 Projection
4 years	20.3	21.0	21.4
10 years	20.3	21.0	21.9

† Based on actual data (as submitted to the EPA), unadjusted basis.
Source: SRI International, Ford, General Motors, Chrysler

Table 8 presents the FE projections for the LDT fleet by EPA class. Note that LDT EPA classes are different from those for passenger cars. LDT classes are based on physical characteristics rather than interior volume. For this analysis, SRI relied on the manufacturers' product plans as to which future vehicles would be assigned in which EPA classes. The volume fractions (equivalent to percentage sales mix) were derived from the manufacturer-furnished sales data for both Tables 6 and 8.



SOURCE: SRI International

FIGURE 4 U.S. LIGHT-DUTY TRUCK FLEET FUEL ECONOMY OUTLOOK
(Domestic, and Import)

Table 8
LIGHT-DUTY TRUCK FLEET FUEL ECONOMY PROJECTIONS, BY EPA CLASS

	MY 1990		MY 1995				MY 2001			
			4-yr Payback		10-yr Payback		4-yr Payback		10-yr Payback	
EPA Class	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction	MPG	Volume Fraction
2WD large pickup	18.6	0.252	18.6	0.102	18.6	0.102	19.1	0.122	19.5	0.122
4WD large pickup	17.4	0.085	18.8	0.101	18.8	0.101	19.9	0.106	20.2	0.106
2WD special purpose	23.1	0.217	22.1	0.293	22.1	0.293	23.2	0.346	23.8	0.346
4WD special purpose	19.6	0.135	19.8	0.203	19.8	0.203	17.7	0.168	18.2	0.169
Cargo van	18.2	0.110	18.5	0.100	18.5	0.100	19.0	0.105	19.6	0.105
Passenger van	20.7	0.089	20.1	0.058	20.1	0.058	20.9	0.038	21.7	0.038
2WD small pickup	25.2	0.112	30.0	0.115	30.0	0.115	30.4	0.056	31.7	0.056
4WD small pickup	22.8	0*	23.4	0.028	23.4	0.028	24.8	0.041	25.1	0.041
Fleet aggregate†	20.3	1.000	21.0	1.000	21.0	1.000	21.4	1.000	21.9	1.000

Note: Volume fractions for 1995 and 2001 are for SRI representative fleet and for 1990 the actual fleet. No data for chassis cab EPA class.

* Negligible.

† Harmonic mean volume-weighted, unadjusted.

Source: SRI International

TECHNOLOGY PENETRATION ANALYSIS

At MVMA's special request, SRI conducted an analysis to determine how individual TI penetration in the fleet would vary over future model years. Based on spreadsheet data for the representative platforms, Table 9 and Table 10 were constructed to show volume-weighted fleet penetrations for major technology changes. The reader is cautioned that some TIs on these tables are mutually exclusive or they overlap and so penetrations are not additive and should not be added to achieve sums greater than 100%. For example, certain transmission TIs, such as lockup versus open converter and CVT versus L4 AT, are mutually exclusive and should not be added. However, with the engine TIs, as another example, split port and tuned intake can be mutually exclusive or additive TIs. Either tuning strategy also can be additive with the VVT TI. Any combination of TIs has to be checked for engineering reasonableness on a case-by-case basis, and this was done at the platform level. Some penetration anomalies also can arise from fluctuations in representative platform volumes. Penetrations were similar in both 4- and 10-yr payback scenarios as product plans and other considerations, such as consumer acceptance, precluded SRI adjustments on many platforms. (See Section IV for a more complete discussion of how we handled TIs differently for different payback periods.)

The results shown in Tables 9 and 10 plus prior discussion of FE gains attainable for major TIs suggest that penetration increases in certain classes of TIs will account for much of the observed future FE gain, such as:

- Fuel delivery systems (MFI/SFI, split port)
- Valve train configurations (RCF, 4V, OHC, light valves)
- Automatic transmission upgrades [electronic automatic transmission (EAT), lockup 5-speed AT (L5)]

Some notable differences with trucks show less penetration in MY 2001 than cars for such TIs as OHC, lockup converters, tuned intake, 4V, EAT, friction reduction, aerodrag reduction, and so forth. This lower penetration reflects the different needs and design philosophies pertinent to LDTs. In addition, trucks in MY 1995 and beyond face substantial weight increases related to safety regulations already absorbed by passenger cars.

Table 9
TECHNOLOGY PENETRATION OUTLOOK: PASSENGER CARS*

		Share of Fleet (%)		
		1995	2001	
Technology Improvement	1990	4- and 10-yr Payback	4-yr Payback	10-yr Payback
Engine				
TBI versus carburetor	24	7	7	7
MFI versus TBI†	75	87	94	94
RCF (pushrod) versus sliding contact	32	54	61	61
RCF (OHC) versus sliding contact	8	25	26	26
OHC versus pushrod	27	45	62	62
VVT (OHC) versus fixed timing	N	6	6	56
4V versus 2V	16	40	46	46
Light valves versus standard	N	17	30	30
Tuned intake versus standard	68	72	79	79
Split port (variable tuning) versus standard	N	20	30	90
Friction reduction versus standard	18	51	52	98
Special lube (synthetic) versus standard	N	100	100	100
CR + 0.5 versus standard	1	100	100	100
Transmission				
Lockup versus open converter	87	88	91	91
4-speed lockup versus 3-speed AT (lockup or open)‡	61	61	70	70
L5AT versus L4AT	N	N	20	20
EAT versus hydraulic control	16	66	76	76
CVT versus L4AT	N	N	7	7
Body/chassis				
Weight increases (1995 versus 1990, 2001 versus 1995)§	N	25	N	N
Weight decreases (1995 versus 1990, 2001 versus 1995)§	N	19	10	10
Aero drag -10% versus base	N	3	7	90
Tires (RR -10% to 15%) versus standard	6	6	100	100
Electric PS versus hydraulic	N	N	5	5
FWD versus RWD	83	86	86	86

Note: N=negligible share of fleet.

*Forecast penetration in SRI-selected representative platforms, volume-weighted, domestic plus import.

†MFI, in this case, includes various multiport fuel injection implementations, including the SFI version. The SFI data were insufficient to separate from MFI.

‡Data are insufficient across the fleet to clearly separate lockup and open converters for this transmission group.

§Various levels unique to each platform. Increases range from 3% to 13% (mostly around 3% to 5%). Decreases range from 3% to 8% (mostly 4% to 5%).

Source: SRI International

Table 10
TECHNOLOGY PENETRATION OUTLOOK: LIGHT-DUTY TRUCKS*

	Share of Fleet (%)			
		1995	2001	
Technology Improvement	1990	4- and 10-yr Payback	4-yr Payback	10-yr Payback
Engine				
TBI versus carburetor	40	18	1	1
MFI versus TBI†	53	82	99	99
RCF (pushrod) versus sliding contact	45	54	88	88
RCF (OHC) versus sliding contact	8	8	N	N
OHC versus pushrod	8	9	28	28
VVT (OHC) versus fixed timing	N	N	32	42
4V versus 2V	N	N	1	1
Tuned intake versus standard	52	66	64	64
Split port (variable tuning) versus standard	N	N	32	72
Friction reduction versus standard	10	26	38	72
Special lube (synthetic) versus standard	N	100	100	100
CR + 0.5 versus standard	N	100	100	100
Transmission				
Lockup versus open converter	80	76	81	81
4-speed lockup AT versus 3-speed AT (lockup or open)‡	80	72	83	83
EAT versus hydraulic control	16	25	25	25
Body/chassis				
Weight increases (1995 versus 1990, 2001 versus 1995)§	N	24	N	N
Weight decreases (1995 versus 1990, 2001 versus 1995)§	N	37	20	20
Aero drag -10% versus base	N	N	20	25
Tires (RR -10% to 15%) versus standard	N	N	100	100

Note: N=negligible share of fleet.

*Forecast penetration in SRI-selected representative platforms, volume-weighted, domestic plus import.

†MFI, in this case, includes various multiport fuel injection implementations, including the SFI version. The SFI data were insufficient to separate from MFI.

‡Data are insufficient across the fleet to clearly separate lockup and open converters for this transmission group.

§Various levels unique to each platform. Increases range from 3% to 6%. Very few decreases were found, mostly around 3%.

Source: SRI International

IV ECONOMIC ANALYSIS

INTRODUCTION

The following review of the economic worthiness of various TIs for use in passenger cars and LDTs is a useful means to sort technology candidates in terms of their ability to pay for themselves in future fuel savings. It also helped SRI to determine which TIs were to be added to future fleets. The manufacturers are placing many of the TIs (which do impact FE) on future vehicle fleets for reasons primarily other than for fuel savings. Other drivers (noneconomic) for inclusion of TIs in manufacturer product plans include competitive factors, marketing/image factors, need for "catch-up" performance, emissions compliance, among others. If the manufacturers included any of these features in their plans, SRI left them in place for this analysis.

Microeconomic price theory implies that a rational consumer will purchase an item whose economic benefits (B) exceed costs (C) or where $\frac{B}{C}$ is greater than 1. Any $\frac{B}{C}$ measurement around 1, however, is marginal and not a strong purchase incentive. For this economic analysis, B = the present value of the future stream of dollar savings in fuel. Other societal economic benefits may be considered—but this analysis assessed only fuel savings. SRI derived a fuel price for each year of future vehicle use (see Appendix D) and established a vehicle miles traveled (VMT) per vehicle per year. (See Appendix E for the VMT values that SRI used.) Please note that all economic analyses in this study used constant 1990 dollar values. The remaining variable in setting B is the "delta c" or change in consumption (gallons per mile) associated with each TI, which is a function of the baseline FE miles per gallon for each scenario. All calculations were made using the city/highway values used for purposes of CAFE calculation as submitted to DOT. (See Appendix A for more details on calculating B).

To determine the C or cost associated with each TI, SRI used a current retail price equivalent (RPE) basis from a variety of sources. In other words, various vehicle manufacturers and component suppliers provided SRI with cost figures for the various TIs as they may appear on vehicle window "stickers" at retail dealerships. As backup, participating MVMA members provided SRI with information on sensitive cost components including variable costs of manufacturing, fixed costs, and corporate- and retail-level markups. Pricing philosophies and other cost assumptions (such as amortized volume) varied from source to source, thereby making a considerable range in RPE values for some TIs. As this was a first-cost analysis, SRI made no attempt to quantify downstream costs, such as special maintenance associated with certain FE TIs. SRI generally did not accept the low- or high-dollar RPE cost values presented but rather selected some reasonable value in between. Subsequent analysis of the cost-effectiveness of the TIs indicated that in most cases the outcome was relatively insensitive to RPE levels—a significant lowering of costs would not render many TIs cost-effective.

Note that early in the economic analysis, SRI made the decision to concentrate on the passenger car situation. Compared with passenger cars, however, light-duty trucks would demonstrate both higher benefits (generally higher annual VMT) and somewhat higher costs (heavier construction, such as transmission upgrades, with less production volume to amortize certain costs).

Later in this section of the report, a fuel-price sensitivity analysis shows how the $\frac{B}{C}$ values fluctuated from the baseline scenario with low (P-20¢ per gallon) and high (P+30¢ per gallon) gasoline pump prices. The final discussion in Section IV deals with macroindustry-level economic issues such as resource limitations.

CONSUMER-LEVEL ANALYSIS OF BENEFITS AND COSTS

SRI began its economic analysis of TIs with an extensive search for all TIs that could be considered for inclusion on MY1995 and MY 2001 vehicles sold in the United States. From this several dozen universe of TIs (all of which could conceivably provide some FE gain), the SRI team sorted out from the beginning those judged to be questionable in terms of meeting future U.S. emissions standards or reliable engineering development (e.g., Miller cycle; 2-stroke cycle, reed valve engines; and other long-term "blue sky" R&D projects). The focus of this screening was to identify real TIs for which manufacturers could commit large investments in tooling in the near term (next several years)—not in the next century. SRI team members reviewed engineering details and held in-depth discussions of the various ways to implement each TI.

Following a preliminary screening of TIs by technical feasibility/market availability, SRI commenced an economic sorting of the TIs determined to be the most promising in relation to FE gains (almost 4 dozen TIs). Tables 11 and 12 show the results of the $\frac{B}{C}$ analysis of the identified TIs in descending order. One key difference between Table 11 and Table 12 is in the FE gain column. For Table 11, SRI assumed that TIs added in MY 1995 would be added on a suboptimal basis owing to short lead-time considerations (that preclude power train matching optimization), so that less-than-full FE gains would be obtained along with performance gains. For Table 12, SRI assumed that with a longer lead time TIs could be implemented in MY 2001 on an optimal FE gain basis, thereby enabling performance to be held constant and a full FE gain to be achieved. Note that for several TIs, such as advanced tires, both tables show the same FE gain and no real performance credit is available to optimize FE gains. In general, the body/chassis TIs did not receive FE gain adjustments for performance but most of the engine-related TIs were adjusted. In some cases, the TI retail costs were not known with certainty but were known well enough to place a TI above or below $\frac{B}{C} = 1$. Some TIs exhibited unusual characteristics, such as negative costs (reduced costs for consumers) and either positive or negative fuel stream savings (an increase or decrease in fuel economy, depending on whether or not the TI was optimized). Some interesting conclusions from the tables are as follows:

- Only a minority of TIs proved cost-effective in all scenarios. (Many are in the product plans anyway).
- A few, such as compression ratio (CR) + 0.5, are obvious "winners" that SRI rolled into the fleet.

- **Some winners (e.g., direct acting bucket [DAB]) met economic tests, but as shown later, failed other tests.**
- **The list of economic TIs grows, as expected,** with longer payback periods (10 yr vs 4 yr) **and with longer term** (MY 2001) purchases when higher gas prices, **and VMTs and FE gains produce** larger streams of fuel savings that can better cover retail costs of TIs.

In reviewing Tables 11 and 12, the reader should be aware that many TIs are mutually exclusive or overlap and should not be added to derive a maximum FE gain.

The SRI team performed a final screening of the winning TIs (all those with $\frac{B}{C}$ exceeding 1) before placing them on 1995 and 2001 car platforms (if not already in the plan). This screening included an adjustment for likely consumer acceptance of the TIs and a final check for compatibility with industry cycle plans, investment limits, and so forth. Section III discussed the applicability, drawbacks, and practical considerations in using several TIs. For example, DAB as opposed to hydraulic valve lash adjustors always showed a cost-effective benefit; in SRI's professional opinion, however, consumers would not universally accept the potentially noisier valve train (solid lifter sound) and higher maintenance burden associated with the DAB TI. Moreover, in one 2001 scenario, the 10% aerodynamic drag reduction is cost-effective for the consumer, but this reduction can realistically be rolled into a platform at only major body cycle changes on a case-by-case basis, where not already done by the OEM. In other words, if the manufacturer made major changes to the car body for 1995 and did not schedule another update, SRI did not force such to reduce drag for 2001. Depending on the manufacturer, major passenger car cycles may fall in the 4- to 8-yr range. Table 13 summarizes the final screening where some economic TIs were set aside for noneconomic reasons.

FUEL PRICE SENSITIVITY

Because this study was designed to evaluate the potential for technological improvements to increase fuel economy without changes in mix or performance beyond that assumed in manufacturer product plans, only one aspect of fuel price sensitivity was measured. Estimating a total responsiveness of miles per gallon to fuel price would also require an analysis of the effect of changed demand for vehicle size, performance, and option packages. Consumers may choose to compromise on any number of other vehicle attributes in response to higher fuel prices, rather than pay for expensive technological improvements. This analysis is beyond the scope of this study.

At MVMA's direction, the SRI baseline gasoline price was both raised 30¢/gallon and lowered 20¢/gallon to measure the impact on benefits and costs for four future scenarios (i.e., 1995 4- and 10-year payback and 2001 4- and 10-year payback). The upper fuel price scenario represents a more extreme gas tax view than SRI's baseline. The lower scenario represents prices for gasoline in a highly optimistic low-tax environment. Again, this analysis was restricted to passenger cars. The results are illustrated graphically in Figures 5, 6, 7, and 8 and backup data are provided in tabular form in Appendix F.

Table 11

TECHNOLOGY IMPROVEMENTS, MY 1995 PURCHASE OF PASSENGER CARS

Rank	TIs (base technology)	SRI Generic FE Gain (%)	Fuel Saved Δ c (90-95) (gpm)	B-Benefit 4 yr ($)	B-Benefit 10 yr ($)	Retail Cost (C) ($)	B/C 4 yr	B/C 10 yr	Remarks
1	CR up 0.5 (std)	1.3	0.00047	22	43	1	22	43	Doable and added by SRI
2	Decel fuel off (fuel on)	1.0	0.00036	17	33	5	2.7	6.7	Emissions problems
3	Spec. lube package (std)	0.3	0.00011	5	10	4	1.4	2.7	Widespread by 1995
4	DAB mech lifter (hydraulic)	1.0	0.00036	17	33	(15)	1.13	2.23	Consumer problems
5	Tires adv rubber (std tires)	1.0	0.00036	17	33	20	0.85	1.67	RR, -10% to 15%
6	Aero drag, -10% (1990 base)	2.4	0.00086	40	79	60	0.67	1.32	Problems for 1995, no interaction
7	TBI (carburetor)	2.6	0.00092	43	85	65	0.67	1.31	Obsolete for emissions
8	RCF pushrod (sliding contact)	2.3	0.00082	38	78	65	0.59	1.17	Largely done by 1995
9	Lockup AT (open converter)	1.7	0.00061	29	56	56	0.51	1.0	Largely done by 1995
10	VVT w/ OHC (fixed timing)	2.6	0.00092	43	85	100	0.43	0.85	Intake phasing only
11	Friction, -10% (std engines)	1.5	0.00054	25	50	60	0.42	0.83	Long lead time
12	Ultra-adv AT (Std AT)	2.0	0.00072	33	66	90	0.37	0.73	Proprietary technology
13	Car wt red, -5% (1990 base)	2.5	0.00089	42	82	120	0.35	0.69	No engrg. interaction
14	RCF OHC (sliding contact)	1.0	0.00036	17	33	50	0.34	0.67	Trend up
15	Tires-- Inj-molded (std tires)	1.0	0.00036	17	33	60	0.28	0.58	RR, -10% to 15%, engrg. not ready
16	Lean/ultra-lean burn (stoichiometric)	8.0	0.0027	127	250	500	0.25	0.50	Emissions problems
17	Split port (single intake)	1.5	0.00054	25	50	100	0.25	0.50	Variable intake tuning
18	Engine wt red Al block (iron block)	1.5	0.00054	25	50	120	0.21	0.42	Trend up
19	SFI (TBI)	2.8	0.00099	47	92	235	0.20	0.39	Best for emissions
20	I4 same size/hp, (V6)	-3.0	-0.0011	(53)	(104)	(300)	0.18	0.35	FE and consumer problems
21	Car wt red, -10% (1990 base)	5.0	0.00174	82	161	470	0.17	0.34	Difficult for 1995
22	Car wt red, -1% (1990 base)	0.5	0.00018	9	17	50	0.17	0.34	Materials substitution, Al for steel
23	MFI (TBI)	1.5	0.00054	25	50	150	0.17	0.33	Good for emissions
24	L4 AT (A3)	2.8	0.00099	47	92	288	0.16	0.32	Interacts with engine
25	Retuned intake (std intake)	0.5	0.00018	9	17	55	0.15	0.31	Many intakes already tuned
26	Eng wt red Al heads (iron)	1.0	0.00036	17	33	150	0.11	0.22	Trend up
27	VVT pushrod (fixed timing)	2.6	0.0009	43	85	500	0.09	0.17	Best with OHC base
28	L4 AT (L3)	1.1	0.00039	19	37	230	0.08	0.16	Almost standard
29	Electric AT (hyd control)	0.5	0.00018	9	17	122	0.07	0.14	Cars ahead of trucks

Table 11 (concluded)

Rank	TIs (base technology)	SRI Generic FE Gain (%)	Fuel Saved Δc (90-95) (gpm)	B=Benefit 4 yr ($)	B=Benefit 10 yr ($)	Retail Cost (C) ($)	B/C 4 yr	B/C 10 yr	Remarks
30	4-V/SOHC (2-v/SOHC)	1.6	0.00057	27	53	400	0.07	0.13	Not popular
31	2-speed accessory (1-speed)	0.7	0.00025	12	23	200	0.06	0.12	Long lead time
32	Al head combustion benefit (iron)	0.5	0.00018	9	17	150	0.06	0.11	Good for emissions
33	Light valve train (std)	0.5	0.00018	9	17	165	0.05	0.10	Titanium parts
34	Car wt red, -20% all Al (steel)	13.0	0.0042	197	388	3,710	0.05	0.10	Assumes current Al prices
35	4-V head (3-v/SOHC)	0.8	0.00029	14	27	275	0.05	0.10	Few 3-V heads to convert
36	3-V /SOHC (2-v/SOHC)	0.8	0.00029	14	27	275	0.05	0.10	4-V preferred
37	OHC (Pushrod)	1.1	0.0004	19	37	400	0.05	0.10	Performance image for cars (not trucks)
38	4-V/DOHC (2-v/SOHC)	1.6	0.00057	27	53	650	0.04	0.08	High end mainly
39	CVT (L4)	1.0	0.00036	17	33	410	0.04	0.08	Considered only for smallest cars
40	L5 AT (L4)	0.5	0.00018	9	17	300	0.03	0.06	Trend up
41	SFI (MFI)	0.0	0	0	0	40	0	0	Trend up for emissions
42	V6 (V8)	0.0	0	0	0	(250)	0	0	Consumer acceptance problems, esp. trucks
43	Supercharged gas (natural aspir)	0.0	0	0	0	2,235	0	0	Displacement, -25%
44	Turbocharged gas (natural aspir)	-3.0	-0.0011	(53)	(104)	2,235	-0.02	-0.05	Displacement, -25%
?	FWD layout (RWD)	0.3	0.00011	5	10	>25	<1	<1	Packaging benefits
?	Electric power steering (hydraulic)	1.4	0.0005	24	47	>60	<1	<1	Long lead time

Source: SRI International

Table 12
TECHNOLOGY IMPROVEMENTS, MY 2001 PURCHASE OF PASSENGER CARS

Rank	TIs (base technology)	SRI Generic FE Gain' (%)	Fuel Saved Δ c (1995-2001) (gpm)	B–Benefit 4 yr ($)	B–Benefit 10 yr ($)	Retail Cost (C) ($)	B/C 4 yr	B/C 10 yr	Remarks
1	CR +0.5 (1995 base)	2.0	0.00070	46	85	1	46.7	85.1	Optimized across board
2	Decel fuel off (fuel on)	1.0	0.00035	23	42	5	4.72	8.60	Emissions problems
3	DAB mech (hydr lifter)	1.5	0.00053	35	64	(15)	2.35	4.28	Consumer problems
4	Spec. lube package (std)	0.3	0.00011	7	12	3	1.90	3.46	Done in 1995
5	Tires (-10% to 15% RR red.)	1.0	0.00035	23	42	20	1.18	2.15	Added across board
6	Aero drag, -10% (1995 base)	2.4	0.00084	56	102	60	0.93	1.70	Selectively done
7	TBI (carburetor)	2.6	0.00090	60	110	65	0.93	1.69	Moot-obsolete
8	Lockup AT (open converter)	2.0	0.00069	46	85	58	0.84	1.52	Done across board
9	RCF pushrod (sliding contact)	2.3	0.00080	53	97	65	0.82	1.50	Done across board
10	Friction, -10% (std engines)	2.0	0.00070	46	85	60	0.78	1.42	Selectively done
11	Split port (single intake)	3.0	0.00104	69	126	100	0.69	1.26	Trend up from 1995
12	VVT w/ OHC (fixed timing)	2.6	0.00090	60	110	100	0.60	1.10	Trend up from 1995
13	Ultra-adv AT (Std AT)	2.0	0.00070	46	85	90	0.52	0.95	Proprietary
14	Car wt, -5% (1995 base)	2.5	0.00087	58	105	120	0.48	0.88	Typical goal
15	RCF OHC (sliding contact)	1.0	0.00035	23	42	50	0.47	0.86	Not as urgent as pushrod
16	Tires– inj-molded (std)	1.0	0.00035	23	42	60	0.39	0.72	Adv rubber preferred
17	SFI (TBI)	4.0	0.00137	91	167	235	0.39	0.71	To replace MFI
18	Lean/ultra-lean burn (std)	8.0	0.00264	176	321	500	0.35	0.64	Emissions problems
19	MFI (TBI)	2.0	0.00070	46	85	150	0.31	0.57	Fully replaces TBI, loses to SFI
20	Engine wt red Al block (iron)	1.5	0.00053	35	64	120	0.29	0.53	Trend up
21	Car wt , -10% (1995 base)	5.0	0.00170	113	206	470	0.24	0.44	Typical max achievement
22	Car wt , -1% (1995 base)	0.5	0.00018	11	21	50	0.24	0.43	Not popular
23	L4 AT (A3)	2.8	0.00097	64	118	286	0.22	0.41	Extensive conversion
24	Retuned intake (std)	0.5	0.00018	11	21	55	0.22	0.39	Selective optimization
25	4v/SOHC vs 2v/SOHC	3.0	0.00104	69	126	400	0.17	0.32	Aimed at sportier market
26	Eng wt red Al heads (iron)	1.0	0.00035	23	42	150	0.16	0.29	Standard practice
27	OHC (Pushrod)	2.5	0.00087	58	106	400	0.15	0.26	Trend up

Table 12 (concluded)

		SRI Generic FE Gain*	Fuel Saved Δ c (1995-2001)	B–Benefit		Retail Cost (C)	B/C	B/C	
Rank	Tis (base technology)	(%)	(gpm)	4 yr ($)	10 yr ($)	($)	4 yr	10 yr	Remarks
28	VVT pushrod (fixed)	2.6	0.00090	60	110	600	0.12	0.22	Too costly
29	L4 (L3)	1.1	0.00039	25	47	230	0.11	0.21	Almost complete conversion
30	4-v /SOHC (3-v/SOHC)	1.3	0.00046	30	65	275	0.11	0.20	3 v to disappear
31	3-v /SOHC (2-v/SOHC)	1.3	0.00046	30	55	275	0.11	0.20	3 v to disappear
32	CVT (L4)	2.0	0.00070	46	85	410	0.11	0.21	Selective—small cars only
33	4-V/DOHC (2-v/SOHC)	3.0	0.00104	69	126	650	0.17	0.19	DOHC for certain high end
34	Electronic AT (hydraulic)	0.5	0.00018	11	21	122	0.10	0.18	Standard practice
35	V6 (V8)	1.0	0.00035	23	42	(250)	0.09	0.17	Very limited appeal
36	2-sp accessory (1-sp)	0.7	0.00025	16	30	200	0.08	0.15	Held back by costs
37	Al head combustion (iron)	0.5	0.00018	11	21	150	0.08	0.14	Standard practice
38	Superch. gas (NA)	8.0	0.00264	176	321	2235	0.08	0.14	Trend down
39	Light valve train (std)	0.5	0.00018	11	21	165	0.07	0.13	Cost problems
40	Car wt, -26% all Al (steel)	13.0	0.00410	274	499	3710	0.07	0.13	Too radical —all Al
41	Turbo gas (NA)	5.0	0.00170	113	206	2235	0.05	0.09	Trend down
42	L5 (L4)	0.5	0.00018	11	21	300	0.04	0.07	Trend up
43	I4 (V6)	0	0	0	0	(300)	0	0	Unpopular
44	SFI (MFI)	0	0	0	0	40	0	0	Trend up
?	FWD layout (RWD)	0.5	0.00018	12	22	>26	<1	<1	Max penetration
?	Electric power strg (hyd)	1.4	0.00049	33	60	>60	<1	<1	Trend up

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*Optimal FE basis with performance neutral.
Source: SRI International

Table 13
FINAL SCREENING OF TECHNOLOGY IMPROVEMENTS

	Cost Effective ?				
	MY 1995		MY 2001		
Candidate TIs	4-yr	10-yr	4-yr	10-yr	Remarks—SRI Judgment
1. RCF-Pushrod	No	Yes	No	Yes	Yes, 10 yr 2001 only, but common by 1995
2. TBI vs carb	No	Yes	No	Yes	Yes, all 10-yr but mostly superceded by MFI
3. V6 vs V8	No	No	Yes*	Yes*	No, consumer problems
4. VVT-OHC in place	No	No	No	Yes	Yes, only 2001/10 yr
5. Split port	No	No	No	Yes	Yes only 2001/10 yr
6. DAB vs hydraulic	Yes	Yes	Yes	Yes	No (consumer problems)
7. Decel fuel off	Yes	Yes	Yes	Yes	No, consumer and emission problems
8. CR+0.5	Yes	Yes	Yes	Yes	Yes, doable 1995 across the board
9. Friction red pkg	No	No	No	Yes	Yes, 2001 10 yr only in case-by-case
10. Lockup converter	No	Yes	No	Yes	Yes, 10 yr but essentially done by 1995
11. Aero drag, 10%	No	Yes	No	Yes	Yes, only 2001 10-yr case-by-case
12. Tire upgrade	No	Yes	Yes	Yes	Yes, 2001 across the board
13. Lube package	Yes	Yes	Yes	Yes	Yes, doable 1995 across the board

Note: Baseline fuel price basis.

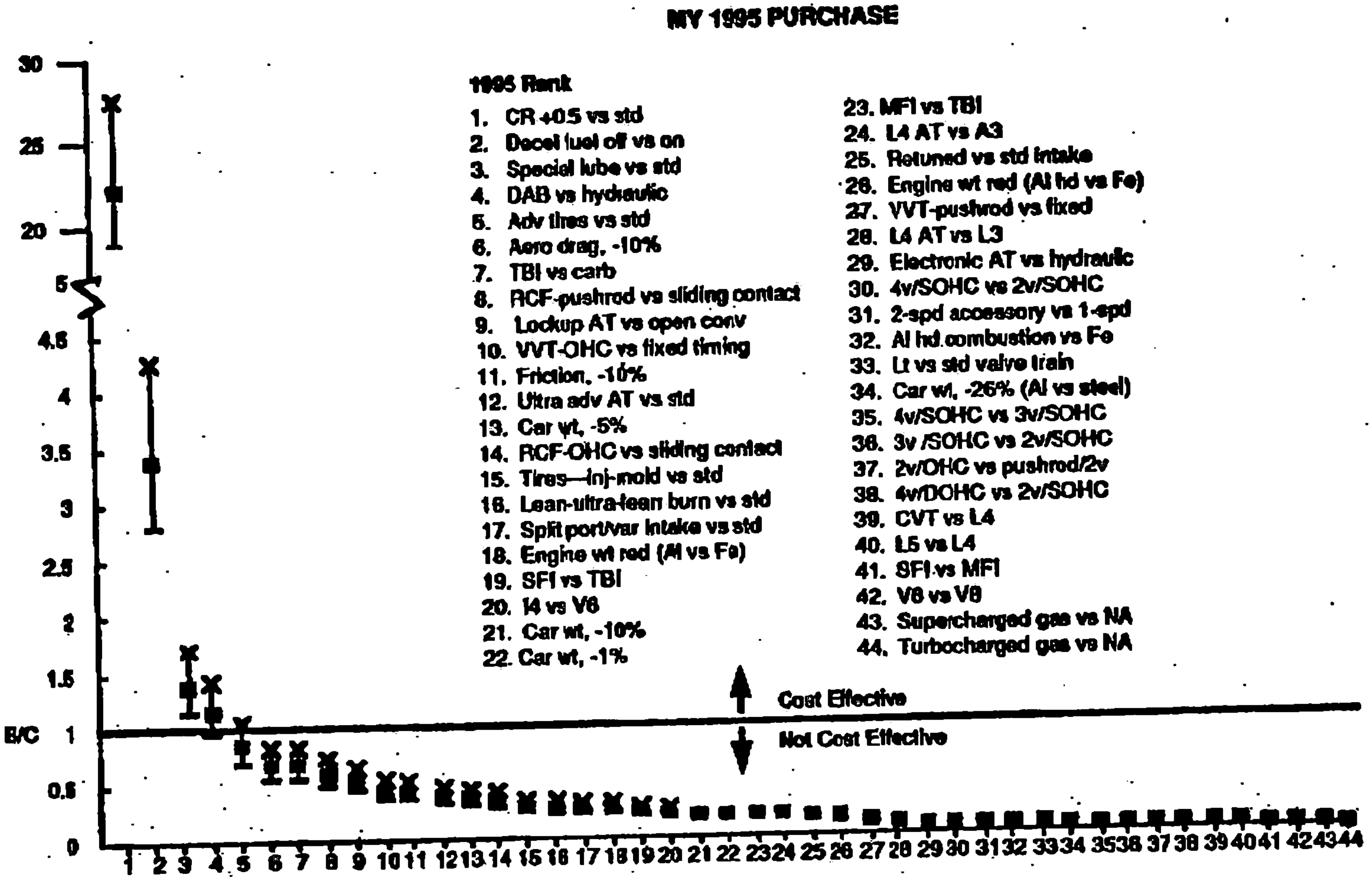
*Raw $\frac{B}{C}<1$ but gives cash back and fuel savings in optimal 2001 case.

Source: SRI International

Fuel prices do have some impact on the appropriate level of technological improvement in fuel economy. Although this analysis indicates that modest fuel price variations have little effect on the number of winning (cost-effective) TIs, increases in fuel prices tend to discourage discretionary driving (decrease VMT) and shift the sales mix toward more fuel-efficient models.

INDUSTRY-LEVEL ECONOMIC ASPECTS

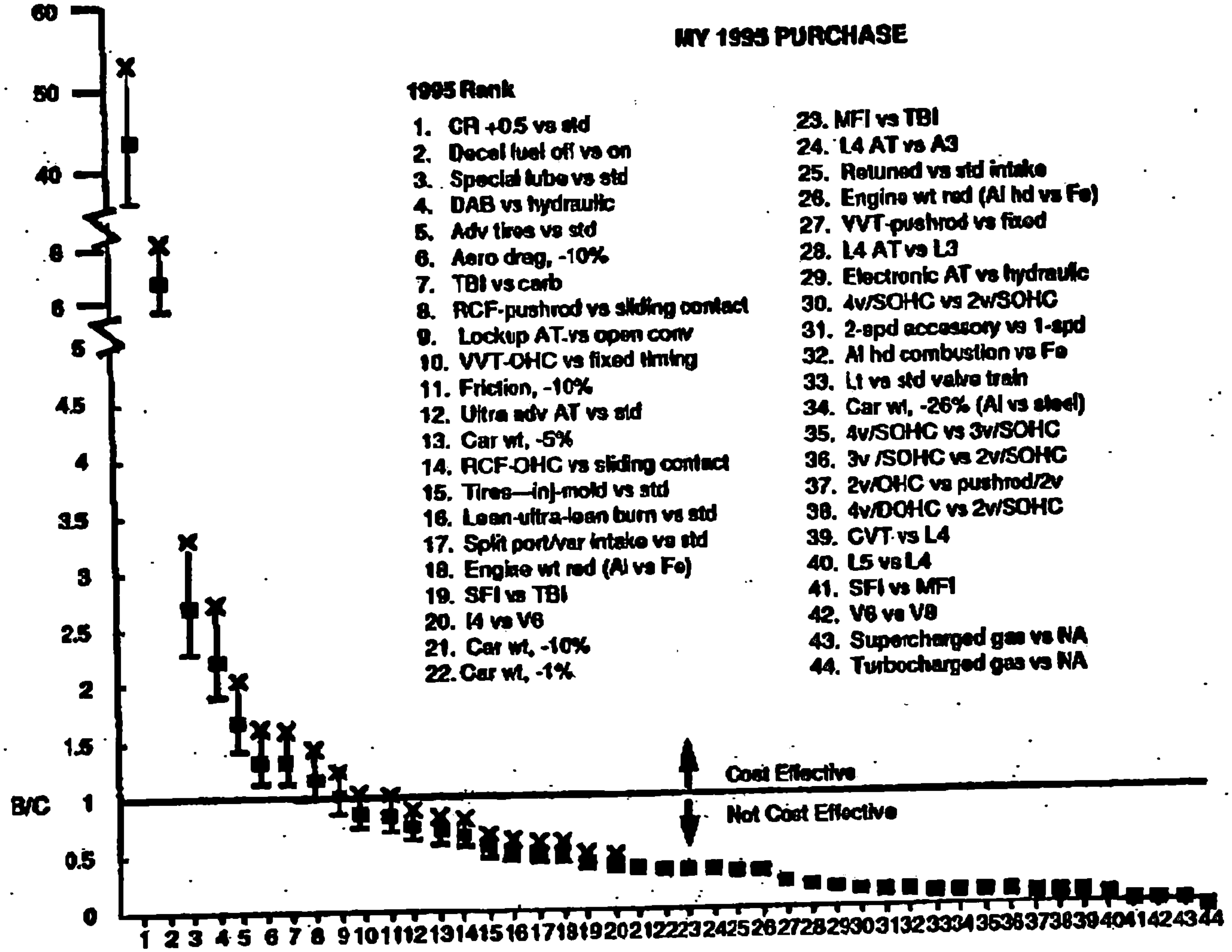
As a final part of the economic analysis, the SRI team examined some significant overall issues that influence the ability to generate FE gains, such as investments and resource limitations. Under the contract conditions, net industry employment was to remain constant and engineering resources would be more or less fixed. The engineering staff at the vehicle manufacturers presently has to deal with other serious challenges besides CAFE and FE enhancement (e.g., emissions and safety laws that are not negotiable). Some members of the industry have transferred a portion of the growing engineering load to outsiders, such as systems vendors. Such outsourcing has limits, however, if the OEM wants to retain valuable control over costs and crucial product aspects such as competitive technical advantages and warranty performance. The SRI team discovered that the engineering staffs are already largely committed to other high-priority projects (many regulatory items) for years to come. Considerable engineering effort is also devoted to evolutionary updates and replacements of power trains and platforms according to the automaker's cycle plan. As these come up for redesign, certain TIs can be rolled in the redesign with some additional effort and expense per vehicle; because of finite human, facilities, and financial resources, however, this opportunity would be more limited if dedicated FE gains were pushed on a crash basis.



Key: X = B/C with P + $0.30/g; ■= B/C with P (baseline); — = B/C with P -$0.20/g

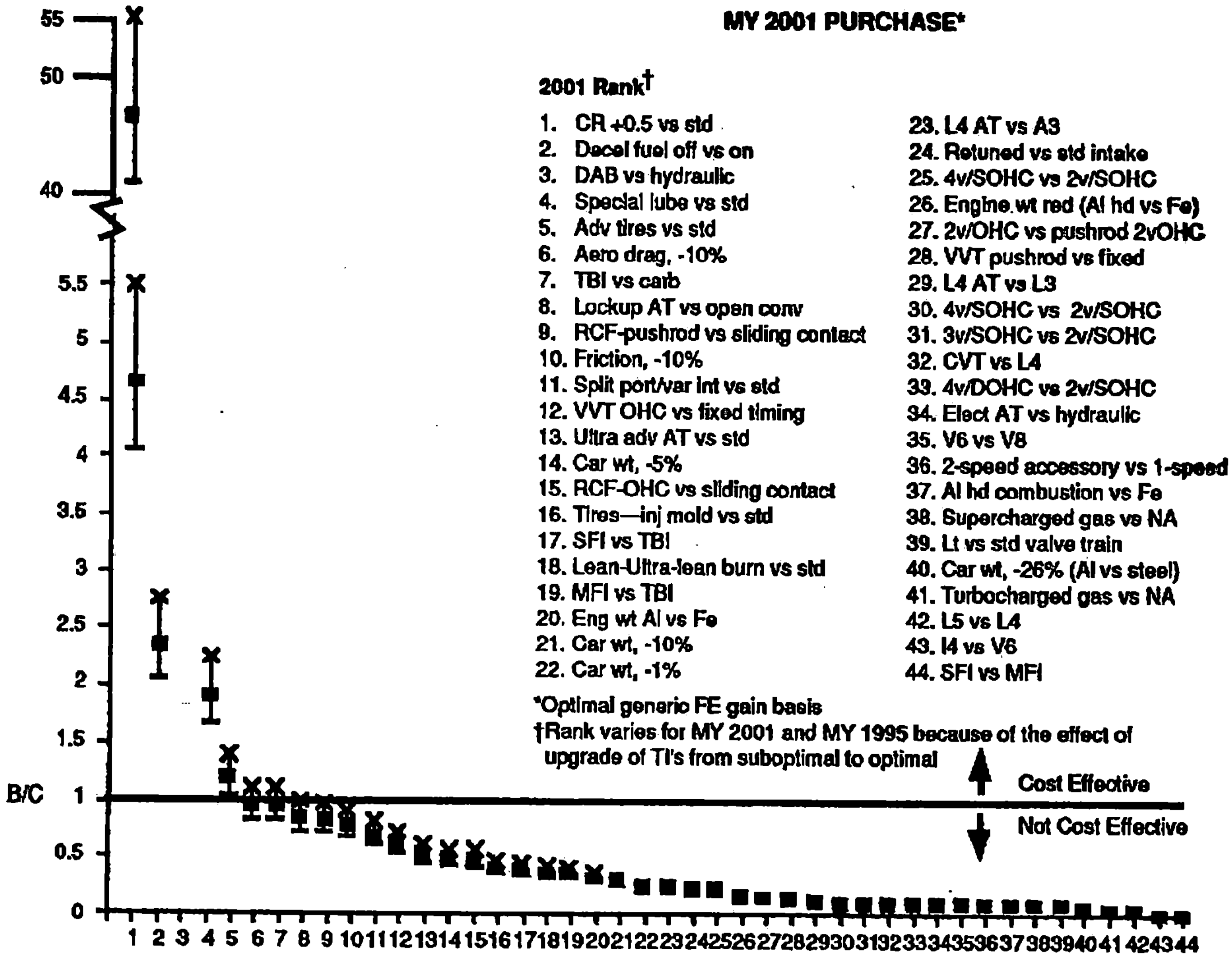
SOURCE: SRI International

FIGURE 5 FUEL PRICE SENSITIVITY, MY 1995 PASSENGER CAR PURCHASE, 4-YEAR PAYBACK



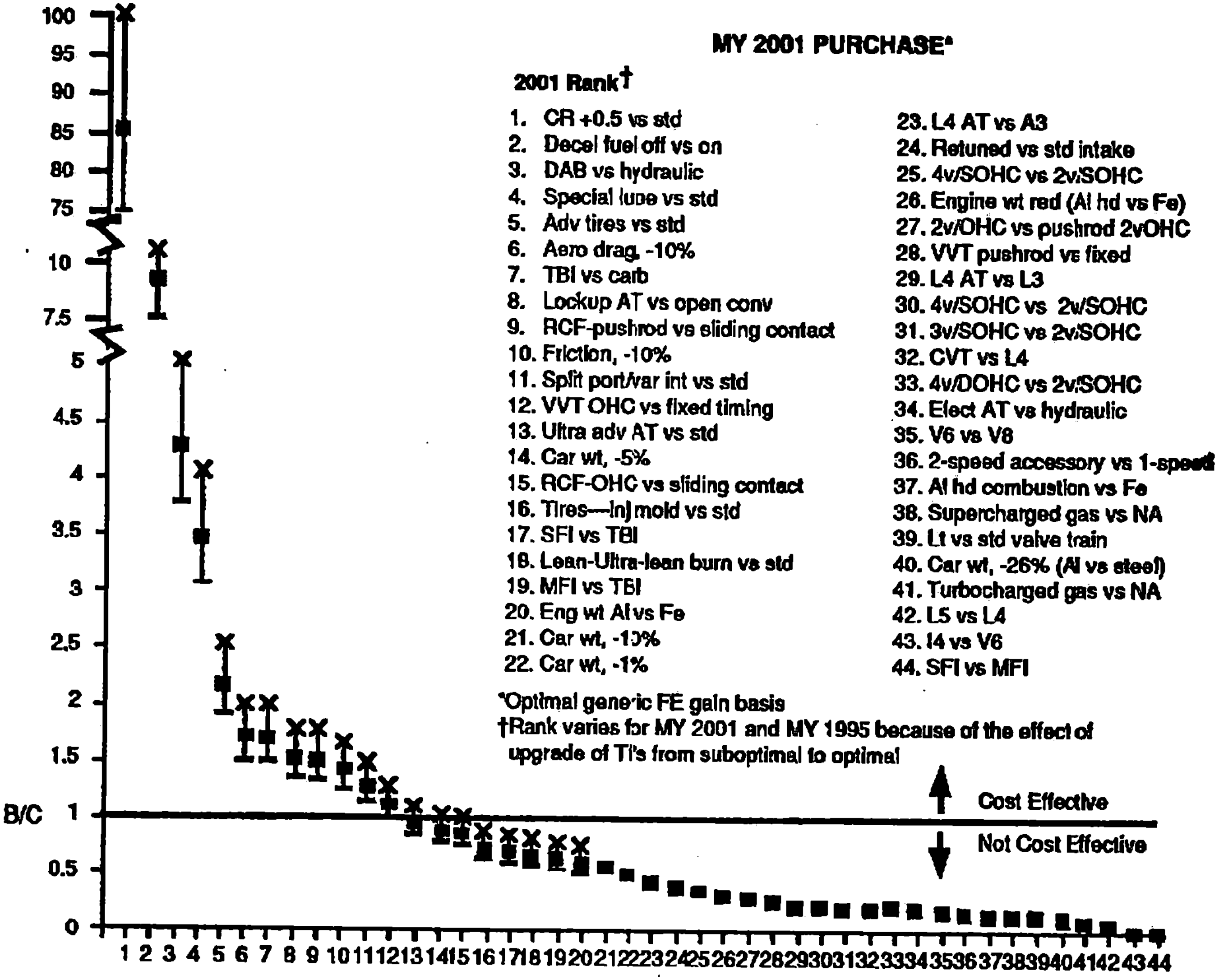
Key: X = B/C with P + $0.30/g; ■ = B/C with P (baseline); — = B/C with P -$0.20/g
SOURCE: SRI International

FIGURE 6 FUEL PRICE SENSITIVITY, MY 1995 PASSENGER CAR PURCHASE, 10-YEAR PAYBACK



Key: X = B/C with P + $0.30/g; ■ = B/C with P (baseline); ▬ = B/C with P -$0.20/g
SOURCE: SRI International

FIGURE 7 FUEL PRICE SENSITIVITY, MY 2001 PASSENGER CAR PURCHASE, 4-YEAR PAYBACK



Key: X = B/C with P + $0.30/g; ■ = B/C with P (baseline); — = B/C with P -$0.20/g
SOURCE: SRI International

FIGURE 8 FUEL PRICE SENSITIVITY, MY 2001 PASSENGER CAR PURCHASE, 10-YEAR PAYBACK

The annual capital budgets that all of the manufacturers have available to spend on new vehicles reflect in total the funding that corporations can earn from continuing operations, the amount they can comfortably borrow in debt funding, and what the equity markets will allow them to raise. A review of such proprietary figures for participating MVMA members suggests a U.S. ceiling of about $12 billion in average annual spending during the 1990s. Most of this funding is set aside for purposes other than FE enhancement such as market-driven upgrades. Thus, the manufacturers clearly are capital constrained in their ability to add FE technology.

Appendix A

SRI METHODOLOGIES AND SAMPLE CALCULATIONS

Appendix A

METHODOLOGY AND SAMPLE CALCULATIONS

INTRODUCTION

SRI's CAFE analysis for MVMA is in some ways similar to that performed by other independent analysts. SRI's methodology built CAFE projections from a baseline case, MY 1990. To determine CAFE estimates, the SRI methodology also used sales-weighted data that were harmonically averaged over the given passenger cars and LDTs. See Figure A-1 for the general sequence of key operations performed to forecast FE. Detailed examples will follow.

Unlike other studies that use only domestic data to predict CAFE, volume data used in the SRI analysis included both domestic and import production offered for sale in the United States. Further, SRI obtained highly proprietary, detailed data such as product changes, estimated shipment volumes, technology changes, company product plans, and technology costs. Note that this information did *not* hold the product mix constant as was assumed in other studies. SRI's methodology produced forecasts of FE capability lower than forecasts made in other studies. SRI attributes this lower forecast to the more realistic technology usage rates applied that reflect a proper consumer perspective (i.e., SRI only added technologies that are cost-effective and consumer-acceptable) and that fully consider industry capabilites (financial, human, facilites) to implement advanced technologies by 1995 and 2001

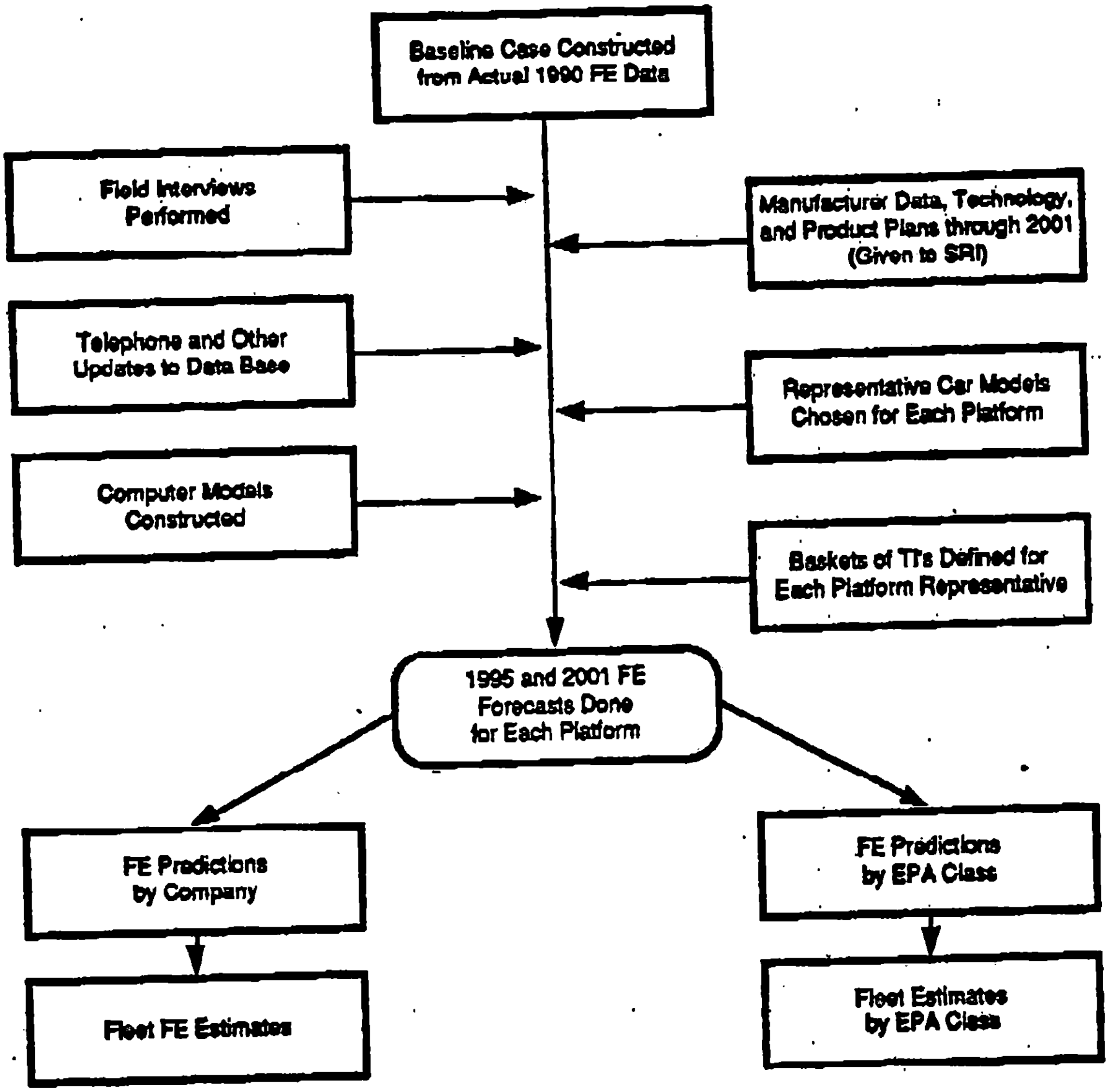
DESCRIPTION OF THE METHODOLOGY

From the data obtained and SRI information such as engineering and economic assessments of TIs, SRI developed detailed projections of FE for 1995 and 2001 for each participating manufacturer. Using SRI's individual company CAFE projections, the team then estimated FE for the entire fleet. To develop these fleet-wide projections, SRI changed the individual company's CAFE estimates from miles per gallon to consumption [gallons per mile (gpm)] and then applied sales-weighted, harmonic-averaging methods to aggregate the results (as specified in federal CAFE regulations).

SRI's FE projections were based on the following conditions:

- SRI included FE improvements in manufacturer product plans that assumed no new radical CAFE legislation.
- SRI baseline estimates of fuel prices were used in selecting cost-effective TIs for each platform.
- SRI made no deletions from the manufacturers' product plans, but minor modifications were made.

- TIs that SRI added to the product plans were judged to be market-available, cost-effective, compatible with environmental and safety standards, and consumer-acceptable.



SOURCE: SRI International

FIGURE A-1 FUEL ECONOMY FORECASTING PROCEDURE

The SRI FE projections for each manufacturer in 1995 and 2001 are extremely data-intensive and proprietary. Thus, the results were summarized into FE projections for the car and truck fleets as a whole. Unless noted otherwise, the analyses for projecting FE for LDT fleets parallels the methodology used for projecting FE for passenger car fleets.

The SRI estimates of FE gains were based on incremental TIs from the 1990 scenario. This 1990 baseline FE scenario included unadjusted, combined metro-highway results for miles-per-gallon calculations. To determine the overall effects of TI on FE in the 1995 and 2001 scenarios, SRI added the TI effects from a "basket" of TIs (manufacturers' product plans plus SRI TIs), accounting for the change in penetration rates for each TI from 1990 to 1995 to 2001. Note that this basket for each platform was checked to ensure that only logical TIs were contained and mutually exclusive TIs were not contained. Where a specific weight difference was discernible between the 1990 baseline platform and future representative platforms, SRI rolled in a custom TI for weight adjustment (plus or minus FE gain) on a case-by-case basis that incorporated weight penalties for safety and environmental regulations. Many such roll-ins occurred between 1990 and 1995, and the trucks in particular suffered from safety-related weight boosts. Page 13 and footnotes to Tables 9 and 10 described the magnitude of weight adjustments.

In that credits for technologies such as alternative fuels are not to be used to set capability standards, no credits were discussed or allowed in this analysis. In other words, SRI performed the entire analysis on an unadjusted basis.

SRI considered using a multiplicative method to determine the cumulative effect of TIs on fuel economy. But, because the miles-per-gallon gains were small, SRI used the additive method, which is judged to be mathematically equivalent. As expected, large variations appeared in the technologies used and in the technology penetration rates among the various manufacturers. Tables 9 and 10 in Section III of the main text provide SRI's assessments of fleet penetrations for each TI.

Various combinations of TIs are used on cars (or LDTs), thus requiring a way to handle the additive effects of groups of variables. To accomplish this, SRI applied an engineering interaction factor (EIF) to dilute sums of TI FE gains for projecting the overall effect of the TIs on FE. This adjusts for the engineering reality that actual gains seen on the dyno for a group of TIs generally are less than the predicted sum of the individual TIs. For use in this analysis, a MVMA member gave SRI the factor 0.88, that developed as a result of sophisticated engineering tests and complex computer-generated simulation models. This EIF covers the most important first-order engineering interactions, such as pumping losses.

Note that FE losses from negative TIs, such as weight gains, were handled differently from FE gains. In several cases, a positive basket of TIs was offset by a sizable weight gain. The EIF in this case (for the negative miles-per-gallon factor alone) was 1.0 because moderate weight adjustments do not usually interact with other TIs.

The team assumed that the same generic percentage of FE gains for certain TIs would be usable for both cars and LDTs. The collection (baskets) of TIs for cars versus trucks, however, were widely different. For example, the OHC TI has low penetration in LDTs compared with that of passenger cars. Entirely separate spreadsheets were run for the LDT fleet.

SRI's methodology and formulas were set up so that a baseline correction factor was not needed in the analysis. Because the 1995 fleet was always compared with the 1990 baseline fleet, improvements from TIs already present in 1990 and their respective changes in penetration rates for the future were considered. SRI did not estimate changes as an improvement over a fantasy fleet of unimproved vehicles. Thus, a baseline correction factor was not required to accurately describe FE gains in the fleets over time.

As the 1995 analysis used 1990 as a base year, SRI based the 2001 estimates upon 1995 penetration rates and levels of technologies. Therefore, the change from existing 1995 penetration and technologies were the important factors considered. Harold Javitz, Ph.D., of

SRI, (an expert in computational statistics) reviewed and verified this method, as well as other mathematical assumptions.

As the number and variation of power train combinations was too large to analyze with available time and funding, SRI chose a representative model configuration from each car and truck platform. The SRI team then thoroughly analyzed this representative configuration for technology similarities and differences compared with the 1990 baseline vehicle configuration. In this analysis, the representative model chosen was the projected unit sales volume leader in each platform. Therefore, the 1995 and 2001 CAFE projections are based on a representative sample of the projected sales. Considering MY 1995, for example, SRI's representative fleet coverage included 55% of passenger cars and 47% of LDTs forecast by the MVMA members. In MY 2001, SRI's representative fleet coverage was 62% of passenger cars and 44% of LDTs forecast by the MVMA members. In general, the typical models used in SRI's analysis (as evident in the product plans) are newer, more technically advanced vehicles that will account for the bulk of future shipments. Thus SRI's vehicle selection is believed to be a justifiable representation for the future fleet.

To summarize again, SRI performed the following tasks to forecast the FE:

- Selected a representative high-volume vehicle model, or model configuration, in each platform group
- Determined for each representative platform which TIs would be adopted (either because the TI was in the manufacturer product plans or otherwise met contract conditions) and how TI penetration would vary with time
- Applied the generic FE gain for each TI
- Computed the resultant net FE gain for each representative platform
- Aggregated platform results (harmonic average) by company and for the fleet.

A numerical example of 1995 FE projections for two hypothetical platforms is shown in Table A-1 to illustrate how the EIF was handled. An example for 2001 would be similar except that changes in TI penetration from 1995 would be used and new more optimal FE gains would be subsituted for each TI.

Table A-2 presents an example of the harmonic mean, or average, used in the analysis of miles per gallon. Table A-3 demonstrates the benefit/cost analysis of technology improvements.

Table A-1
EXAMPLE OF FE GAIN FORECAST
(Percent)

			Hypothetical Platforms	
TI	1990–1995 Change in Penetration	Generic FE Gain	Apple Net FE Gain	Orange Net FE Gain
Weight reduction	50	+3	1.5	
Weight increase	50	−3		−1.5
Split port	100	1.5	1.5	1.5
4V	100	1.0	1.0	1.0
CR +0.5	100	1.3	1.3	1.3
EAT	100	0.5	0.5	0.5
Subtotal positive FE gains (%)			5.8	4.3
x 0.88 EIF =			5.1	3.8
Subtotal negative FE gains (%)			0	−1.5
x 1.0 EIF =			0	−1.5
Net FE gains (%) =			5.1	2.3
Base 1990 FE (mpg)			26.0	27.5
New 1995 FE (mpg)			27.3	28.1

Source: SRI International

Table A-2
HARMONIC MEAN EXAMPLE USED IN THE MPG ANALYSIS

Harmonic mean = $(1/(\Sigma f_n c_n))$
f_n = market share
c_n = consumption = gpm = 1/mpg
n = number of samples

Company	Representative Volumes (x1000)	Est'd Co. mpg	c_n (gpm)	f_n (%)	$f_n c_n$	$\Sigma f_n c_n$	Fleet CAFE (1/Σ)
A	400	28.02	0.0357	18.18	0.00649		
B	500	27.01	0.0370	22.73	0.00841		
C	600	30.04	0.0332	27.27	0.00908		
D	700	29.03	0.0344	31.82	0.01096		
						0.03494	28.62

Source: SRI International

Table A-3
TECHNOLOGY IMPROVEMENT BENEFIT/COST ANALYSIS

FE gain 1995: generic suboptimal FE gains (%)from each TI
FE gain 2001: generic optimal FE gains (%) from each TI
1990 CAFE = mpg based on actual 1990 data/results
Consumption "c" = gpm = 1/mpg
n: travel years
VMT : Σ vehicle miles traveled per vehicle per year for n travel years (4 or 10)
P_n = price of fuel in \$/gallon for year n
DF_n= present value of \$1 = $1/(1+i))^n$, (i=10%), for n years of travel
Present value = PV = $\Sigma\ VMT_n\ P_n\ DF_n$. Σ is as n =1 to 4 or 10
Benefit = Δc PV
C = retail cost in \$
$\frac{B}{C}$ = cost-effectiveness ratio

	TI Examples	
	CR up 0.5	L5 vs L4
FE gain (%)	1.3	0.5
'90 fleet CAFE (mpg)	27.4	27.4
'90 "c" (gpm)	0.0365	0.0365
'95 fleet CAFE (mpg)	27.76	27.54
'95 "c" (gpm)	0.0360	0.0363
Δc ('90 - '95)	0.00047	0.00018
PV 4 yr*	59,000	59,000
B 4 yr (\$)	27.73	10.62
C (\$)	1.00	300.00
$\frac{B}{C}$ 4 yr	27.73	0.04

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* Please refer to PV formula above. In this example, P = base + 30¢/gallon.

Source: SRI International

Therefore, CR of +0.5 would be included in the forecasting analysis as its $\frac{B}{C}$ is greater than 1. On the other hand, the technology L5 would not be economically feasible as its $\frac{B}{C}$ is much less than 1. Thus, SRI did not add L5 in the FE projections, although many are already in the product plans.

DEPTH AND BREADTH 1995 AND 2001 COMPANY FORECASTS

The computer models used to project FE encompassed an enormous amount of data. For example, the models to project FE for the passenger car fleet in 1995 required 75,000 different data cells in multiple computer models/electronic spreadsheets.

Areas in which statistical and judgmental errors could occur in this methodology include:

- Estimates of generic FE effects of individual TIs
- Estimates of technology costs

- The use of one car/LDT model to represent an entire platform
- Accuracy or completeness of data supplied to SRI from the manufacturers.

SRI believes that its projected TI gains and FE estimates are reasonable and that they accurately reflect the maximum feasible/practical FE achievable by the participating manufacturers. The uniqueness of being able to use actual manufacturer technology, improvements, cost estimates, and product plans decreased the number of independent judgments that SRI had to make. Although SRI's expert judgments can be questioned, as can any judgments, SRI is an independent organization whose highly qualified professionals provide their unbiased views that are considered more objective than those from industry insiders performing the same kind of analyses.

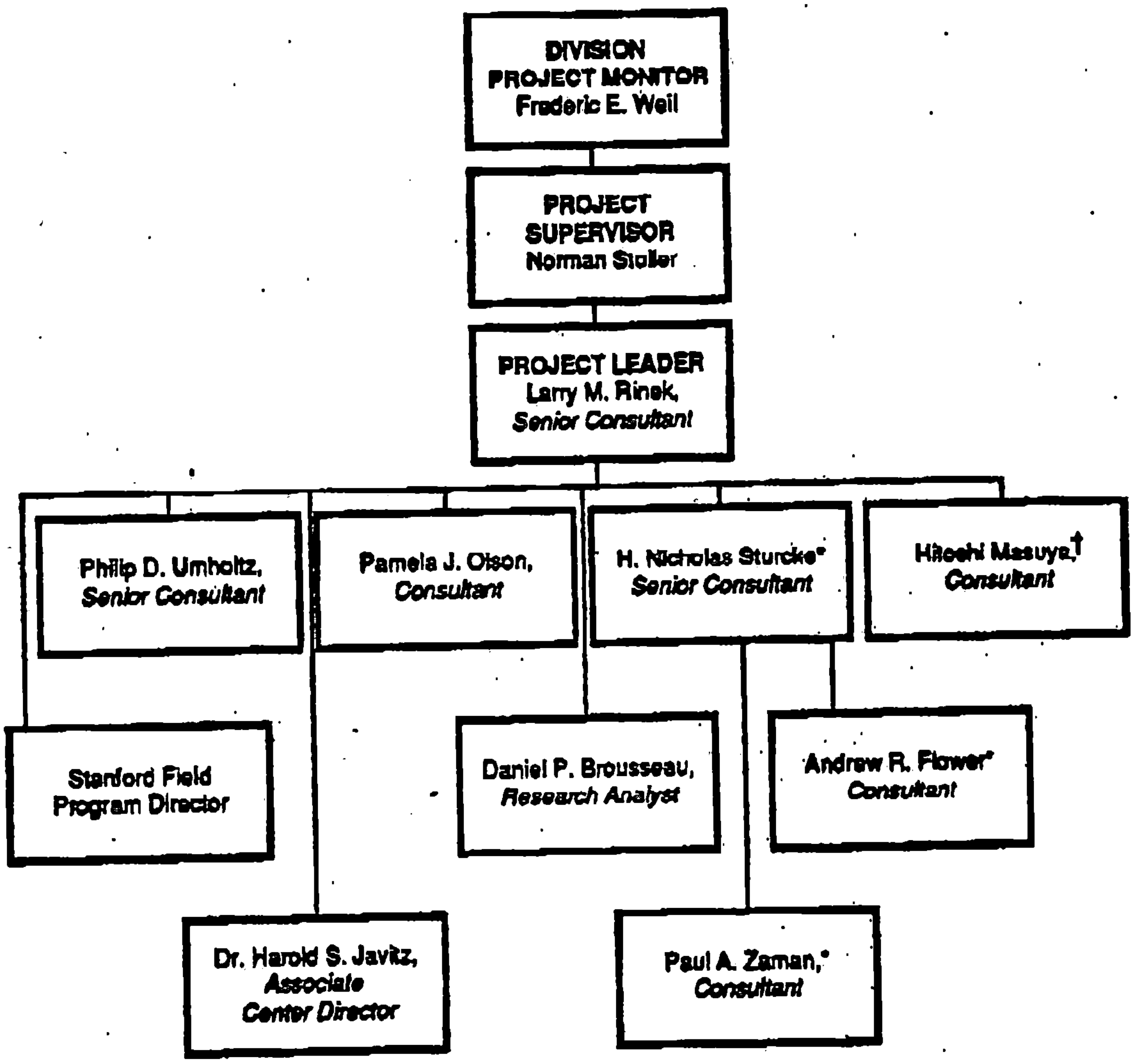
Appendix B

PROJECT TEAM

SRI management assembled and organized a project team of professionals as shown in Figure B-1. The team brought to the assignment a combined work experience that spanned tens of decades and covered a broad spectrum of relevant disciplines including automotive engineering, economic analysis, mathematics, market research, fuel price forecasting, and computer modeling. Project responsibilities are summarized in Table B-1.

Table B-1
PROJECT PROFESSIONAL RESPONSIBILITIES

Professional Staff	SRI Organization	Activities
Frederick E. Weil	205	Division-level review of project
Norman Stoller	205	Project supervisor (chief interface with MVMA on high-level project matters), report production
Larry M.Rinek	224	Project leader (chief of staff), field interviews, mpg analysis (Ford and Honda), economic analysis, report production
Pamela J. Olson	224	Principal computer modeler, security monitor, field interviews, report production
Philip D. Umholtz	224	Principal technology advisor, field interviews, mpg analysis (Chrysler and GM)
Daniel P. Brousseau	107	Literature search, spreadsheet data entry and analysis
H. Nicholas Sturcke	288	Supervisor, European investigation
Andrew R. Flower	288	European investigation, field interviews
Paul A. Zaman	288	European investigation
Hitoshi Masuya	299	Japanese investigation, field interviews
Harold S. Javitz	244	Mathematics and statistics consultant
Stanford Field	164	Energy consultant



*Based at SRI's office in Croydon, (London) England
†Based at SRI's East Asia regional office in Tokyo, Japan

FIGURE B-1 PROJECT PROFESSIONAL STAFFING

Appendix C

SRI FIELD CONTACTS

Table C-1
LIST OF SRI FIELD CONTACTS

ORGANIZATION	VISIT LOCATION
Automotive OEMS	
Chrysler	Highland Park, MI
Ford	Dearborn, MI
General Motors	Warren, MI
Volvo	Rockleigh, NJ
Nissan	Tokyo, Japan
Toyota	Tokyo, Japan
Honda North America	Washington, DC
Fiat	Orbassano, Italy
Volkswagen	Wolfsburg, Germany
Rover Group	Coventry, England
Automotive Suppliers	
R. Bosch	Farmington Hills, MI
Eaton	Southfield, MI
Siemens Automotive	Troy, MI
Lucas Automotive	Troy, MI
Borg-Warner	Utica, NY
Du Pont	Troy, MI
AVL GmbH	Graz, Austria
Others	
University of Michigan	Ann Arbor, MI
U.S. Congress, Office of Technology Assessment	Washington, DC
Energy & Environmental Analysis	Arlington, VA
United Auto Workers	Washington, DC
Environmental Protection Agency	Ann Arbor, MI

Appendix D

SRI FUEL PRICE FORECAST

Appendix D

SRI FUEL PRICE FORECAST

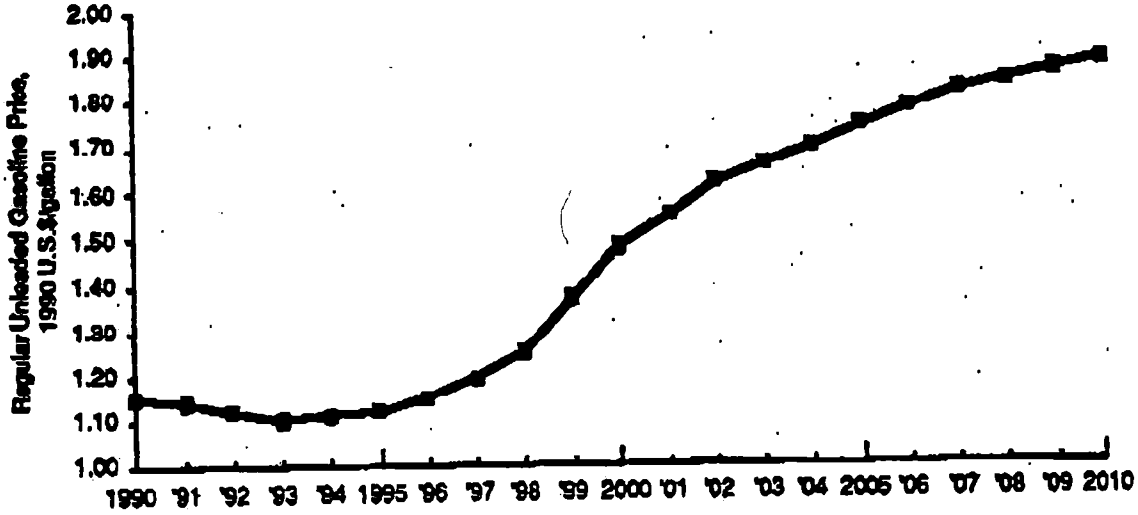
An important factor in determining the economic benefits of fuel-savings technology is the fuel price. For this study, SRI forecast average retail U.S. pump prices for unleaded regular (87 octane) gasoline. Although the scope of the study included diesel vehicles, it was found not necessary to research diesel fuel prices. The participating manufacturers do not plan to offer diesels in their CAFE fleets [passenger cars and LDTs below 8500 lb gross vehicle weight (GVW)] for MY 1995 and 2001, primarily because of exhaust emissions compliance problems (e.g., NO_X).

To generate a fuel price forecast, the team conducted a multistep process that first examined SRI's forecast Arabian light crude oil prices at the wellhead that would be delivered to a U.S. refinery (e.g., Houston, TX). In the next step, the team added gasoline refining costs, including special environmental expenses to comply with 1990 Clean Air Act requirements. Such requirements include the need to reduce Reid vapor pressure, reduce benzene content, limit aromatic content, and add oxygen. Finally, the team added costs for transportation to dealers, dealer margins, assumed state and federal fuel taxes and state and local sales taxes to the finished gasoline price at the refinery gate, thus yielding retail pump prices.

Moderate increases are built into the tax structure as state and federal government demonstrate the need (budget problems) and willingness to raise revenues from this source. Within the past year, sizable increases already were rolled into California and federal fuel taxes. Although an underlying political sentiment exists for raising taxes to discourage fuel consumption, the SRI team did not factor in the 50¢/gallon (or higher) tax that some contemplated. SRI is aware that European governments regularly tax fuel in the $1.50 to $4.00/gallon range, but this was judged not to be politically acceptable in the United States.

The entire analysis was performed in 1990 dollars. Results are shown in the tabulation below and are illustrated graphically in Figure D-1.

Year	Price ($/gallon)	Year	Price ($/gallon)
1990	1.15	2000	1.48
1991	1.14	2001	1.55
1992	1.12	2002	1.62
1993	1.11	2003	1.66
1994	1.11	2004	1.70
1995	1.12	2005	1.74
1996	1.15	2006	1.78
1997	1.19	2007	1.82
1998	1.25	2008	1.84
1999	1.37	2009	1.86
		2010	1.88



SOURCE: SRI International

FIGURE D-1 GASOLINE PRICE FORECAST

Appendix E

PROJECTED ANNUAL MILES TRAVELED PER VEHICLE

Table E-1
PROJECTED ANNUAL MILES TRAVELED PER VEHICLE

Years of	MY 1995 Purchase		MY 2001 Purchase	
Ownership	Passenger Car	LDT	Passenger Car	LDT
1	13,800	15,600	13,900	15,800
2	12,800	14,500	13,200	14,100
3	12,300	14,000	12,600	14,400
4	11,600	13,300	12,000	13,700
5	11,100	12,600	11,400	13,000
6	10,500	11,800	10,800	12,600
7	10,000	11,300	10.300	11,800
8	9,500	10,700	9,800	11,100
9	9,100	10,300	9,300	10,700
10	8,700	9,900	8,900	10,200

Note: Derived by SRI from EPA Mobile 4 data baseline (May 1989) adjusted for expected growth. SRI research indicates that VMT will grow slowly in the long term, with increased availability of leisure time, but short-term fluctuations may occur in response to fuel prices and changes in vehicle fuel efficiency.

Appendix F

FUEL PRICE SENSITIVITY DATA

Table F-1

FUEL PRICE SENSITIVITY DATA (B/C Variation with Fuel Price Level)

	MY 1995 Purchase							MY 2001 Purchase*						
		4-yr Payback			10-yr Payback				4-yr Payback			10-yr Payback		
TI's (Technology Improvements)	1995 Rank	P-0.20	P	P+0.30	P-0.20	P	P+0.30	2001 Rank†	P-0.20	P	P+0.30	P-0.20	P	P+0.30
CR +0.5 vs std	1	18.2	22.0	27.6	36.7	43.3	53.1	1	41.0	46.8	55.4	75.2	85.1	100.2
Decel fuel off vs on	2	2.81	3.39	4.26	5.67	6.68	8.19	2	4.14	4.72	5.59	7.80	8.60	10.12
Spec. lube vs std	3	1.13	1.37	1.72	2.28	2.69	3.30	4	1.67	1.90	2.25	3.06	3.48	4.07
DAB vs. hydraulic	4	0.94	1.13	1.42	1.89	2.23	2.73	3	2.06	2.35	2.78	3.76	4.28	5.03
Adv tires vs std	5	0.70	0.85	1.07	1.42	1.67	2.05	5	1.04	1.18	1.40	1.90	2.16	2.53
Aero drag, -10%	6	0.55	0.67	0.84	1.12	1.32	1.62	6	0.82	0.93	1.10	1.50	1.70	2.00
TBI vs carb	7	0.55	0.67	0.84	1.12	1.31	1.61	7	0.82	0.93	1.10	1.50	1.69	1.99
RCF-pushrod vs sliding contact	8	0.49	0.59	0.74	0.99	1.17	1.43	9	0.72	0.82	0.98	1.33	1.50	1.77
Lockup AT vs open converter	9	0.42	0.51	0.64	0.85	1.01	1.23	8	0.73	0.84	0.99	1.34	1.52	1.79
VVT-OHC vs fixed timing	10	0.36	0.43	0.55	0.73	0.85	1.06	12	0.53	0.60	0.72	0.97	1.10	1.29
Friction, -10%	11	0.35	0.42	0.53	0.70	0.83	1.02	10	0.68	0.78	0.92	1.25	1.42	1.67
Ultra adv AT vs std	12	0.31	0.37	0.47	0.62	0.73	0.90	13	0.46	0.52	0.62	0.84	0.95	1.11
Car, wt, -5%	13	0.29	0.35	0.44	0.58	0.69	0.84	14	0.43	0.48	0.57	0.78	0.88	1.04
RCF-OHC vs sliding contact	14	0.28	0.34	0.43	0.57	0.67	0.82	15	0.41	0.47	0.56	0.76	0.86	1.01
Tires-inj-mold vs std	15	0.23	0.28	0.36	0.47	0.56	0.68	16	0.35	0.39	0.47	0.63	0.72	0.84
Lean-ultra-low burn vs std	16	0.21	0.25	0.32	0.42	0.50	0.61	18	0.31	0.35	0.42	0.57	0.64	0.76
Split port/var intake vs std	17	0.21	0.25	0.32	0.42	0.50	0.61	11	0.61	0.69	0.82	1.12	1.26	1.49
Engine wt red (Al blk vs Fe)	18	0.17	0.21	0.27	0.35	0.42	0.51	20	0.26	0.29	0.35	0.47	0.53	0.63
SFI vs TBI	19	0.16	0.20	0.25	0.33	0.39	0.48	17	0.34	0.39	0.46	0.63	0.71	0.84
I4 vs V6	20	0.15	0.18	0.22	0.29	0.35	0.43	43	0	0	0	0	0	0
Car wt, -10%	21	0.14	0.17	0.22	0.29	0.34	0.42	21	0.21	0.24	0.29	0.39	0.44	0.52
Car wt, -1%	22	0.14	0.17	0.21	0.28	0.34	0.41	22	0.21	0.24	0.28	0.38	0.43	0.51
MFI vs TBI	23	0.14	0.17	0.21	0.28	0.33	0.41	19	0.27	0.31	0.37	0.50	0.57	0.67
L4 AT vs A3	24	0.13	0.16	0.20	0.28	0.32	0.39	23	0.19	0.22	0.26	0.36	0.41	0.49
Retuned vs std intake	25	0.13	0.15	0.19	0.26	0.31	0.37	24	0.19	0.22	0.26	0.35	0.39	0.46
Engine wt red (Al vs Fe)	26	0.09	0.11	0.14	0.19	0.22	0.27	26	0.14	0.16	0.19	0.25	0.29	0.34
VVT-pushrod vs fixed	27	0.07	0.09	0.10	0.15	0.17	0.20	28	0.11	0.12	0.14	0.19	0.22	0.26

Table F-1
(concluded)

	MY 1995 Purchase							MY 2001 Purchase*						
		4-yr Payback			10-yr Payback				4-yr Payback			10-yr Payback		
TIs (Technology Improvements)	1995 Rank	P-0.20	P	P+0.30	P-0.20	P	P+0.30	2001 Rank†	P-0.20	P	P+0.30	P-0.20	P	P+0.30
L4 AT vs L3	28	0.07	0.08	0.09	0.14	0.16	0.17	29	0.10	0.11	0.13	0.18	0.21	0.24
Electronic AT vs hydraulic	29	0.06	0.07	0.08	0.12	0.14	0.16	34	0.09	0.10	0.12	0.16	0.18	0.21
4V/SOHC vs 2V/SOHC	30	0.06	0.07	0.08	0.11	0.13	0.16	25	0.15	0.17	0.21	0.28	0.32	0.37
2-spd access vs 1-spd	31	0.05	0.06	0.07	0.10	0.12	0.14	36	0.07	0.08	0.10	0.13	0.15	0.18
Al hd combustion vs Fe	32	0.05	0.06	0.07	0.10	0.11	0.14	37	0.07	0.08	0.09	0.13	0.14	0.17
LI vs std valve train	33	0.04	0.05	0.06	0.09	0.10	0.12	39	0.06	0.07	0.09	0.12	0.13	0.15
Car wt, -28% (Al vs steel)	34	0.04	0.05	0.06	0.09	0.10	0.12	40	0.06	0.07	0.09	0.12	0.13	0.15
4V/SOHC vs 3V/SOHC	35	0.04	0.05	0.06	0.08	0.10	0.12	30	0.10	0.11	0.13	0.18	0.20	0.24
3V/SOHC vs 2V/SOHC	36	0.04	0.05	0.06	0.08	0.10	0.12	31	0.10	0.11	0.13	0.18	0.20	0.24
2V/OHC vs pushrod 2V	37	0.04	0.05	0.06	0.08	0.09	0.11	27	0.13	0.15	0.17	0.23	0.26	0.31
4V/DOHC vs 2V/SOHC	38	0.03	0.04	0.05	0.07	0.08	0.10	33	0.09	0.11	0.13	0.17	0.19	0.23
CVT vs L4	39	0.03	0.04	0.05	0.07	0.08	0.10	32	0.10	0.11	0.14	0.18	0.21	0.24
L5 vs L4	40	0.02	0.03	0.04	0.05	0.06	0.07	42	0.03	0.04	0.05	0.06	0.07	0.08
SFI vs MFI	41	0	0	0	0	0	0	44	0	0	0	0	0	0
V6 vs V8	42	0	0	0	0	0	0	35	0.08	0.09	0.11	0.15	0.17	0.20
Supercharged gas vs NA	43	0	0	0	0	0	0	38	0.07	0.08	0.09	0.13	0.14	0.17
Turbocharged gas vs NA	44	-0.02	-0.02	-0.03	-0.04	-0.05	-0.06	41	0.04	0.05	0.06	0.08	0.09	0.11

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*Optimal generic FE gain basis.

†Rank varies for MY 2001 and MY 1995 because of the effect of upgrade of TIs from suboptimal to optimal.

Source: SRI International

GLOSSARY

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AT	automatic transmission
CAFE	corporate average fuel economy
CFC	chlorofluorocarbon
CVT	continuously variable transmission
DAB	direct acting bucket
DOHC	dual overhead cam
DOE	Department of Energy (U.S.)
DOT	Department of Transportation (U.S.)
EAT	electronic automatic transmission
EIF	engineering interaction factor
EPA	Environmental Protection Agency (U.S.)
FE	fuel economy
FWD	front-wheel drive
gpm	gallons per mile
GVW	gross vehicle weight
L5, 4, 3	lockup 5-, 4-, 3-, speed automatic transmission
LDT	light-duty truck
MFI	multiport fuel injection
mpg	miles per gallon
MVMA	Motor Vehicle Manufacturers Association
MY	model year
NA	naturally aspirated
NHTSA	National Highway Traffic Safety Administration
OEM	original equipment manufacturer
PV	present value
RCF	roller cam follower
RPE	retail price equivalent
RR	rolling resistance

RWD	rear-wheel drive
SAE	Society of Automotive Engineers
SFI	sequential fuel injection
SOHC	single overhead cam
TBI	throttle body injection
TI	technology improvement
VMT	vehicle miles traveled
VVT	variable valve timing