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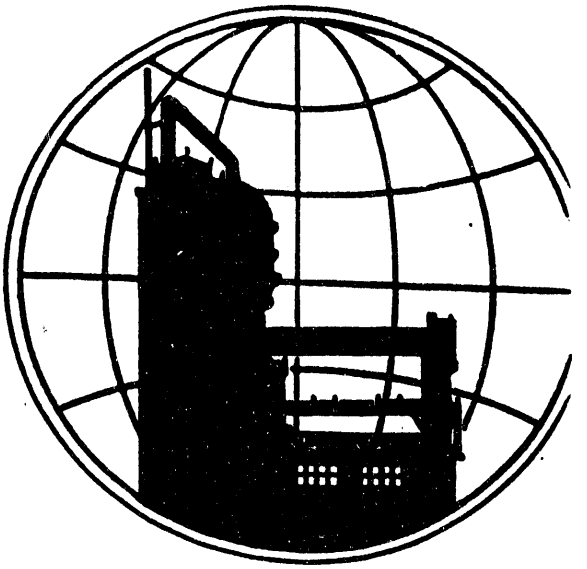
SUMMARY OF THE PROCEEDINGS OF THE WORKSHOP ON THE REFINERY OF THE FUTURE



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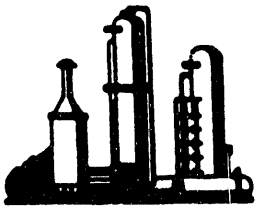

NATIONAL PETROLEUM REFINERS ASSOCIATION

ARGONNE NATIONAL LABORATORY

In Cooperation With:

U.S. DEPARTMENT OF ENERGY

Houston, Texas

February 14-15, 1994

PREFACE

This report on the Workshop on the Refinery of the Future has been prepared for participants to provide them with a succinct summary of the presentations, deliberations, and discussions. In preparing the summary, we have striven to capture the key findings (conclusions) and highlight the issues and concerns raised during the plenary and breakout sessions. The presentation of the summary of the proceedings follows the final workshop agenda, which is given in Section I; each section is tabbed to facilitate access to specific workshop topics.

The material presented relies heavily on the outline summaries prepared and presented by the Plenary Session Chairman and the Facilitators for each breakout group. These summaries are included essentially as presented. In addition, individuals were assigned to take notes during each session; these notes were used to reconstruct critical issues that were discussed in more detail. The key comments made by the participants, which tended to represent the range of views expressed relative to the issues, are presented immediately following the facilitator's summary outline in order to convey the flavor of the discussions. The comments are not attributed to individuals, since in many instances they represent a composite of several similar views expressed during the discussion. The facilitators were asked to review the writeups describing the outcomes of their sessions for accuracy and content; their suggested changes were incorporated. Every effort has thus been made to reconstruct the views expressed as accurately as possible; however, errors and/or misinterpretations undoubtedly have occurred.

The workshop clearly achieved its primary objective—namely, to provide a forum for individuals from the many segments of the refinery industry to express their views and opinions relative to the issues posed. It is hoped that this summary of the proceedings of

the workshop has captured the essence of the views of the industry at this point in time, relative to the many problems and issues it faces, as it prepares to move into the 21st century.

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INTRODUCTION/BACKGROUND

During the past year, the Offices of Industrial Technology and Fossil Energy of the U.S. Department of Energy (DOE) have engaged segments of the refinery industry in a series of meetings that were designed to ascertain the health of the industry and its future direction. The perception was that the industry was facing very serious problems. Specifically, answers were sought directly from the industry to such questions as these: What is the refinery industry's vision of its future? What changes can be expected to occur in the industry; how fast will they occur? What are the key drivers causing change in the industry? Is there refinery industry interest in a collaborative R&D program with DOE? Is there a need for such a program? Why? What type of program would be of interest to the industry? This workshop represents the culmination of this effort.

The Perception

The industry is undergoing major changes that are being driven primarily by governmental regulation and policy. These regulations and policies are having a profound impact on the industry, since they are adversely impacting the industry's costs and market, supply, and demand factors. Major fractions of its cash flows are being diverted from pursuing commercial opportunities to meeting costly regulatory mandates. The industry essentially is becoming a regulated industry. As a result, a number of the problems faced are common to all companies.

As the industry attempts to cope with the critical near-term issues, a majority of the member companies are downsizing and restructuring. The net result has been a major reduction in R&D. A number of companies who have curtailed R&D have indicated their intent to license required new technologies. The industry concern/risk is essentially the question of who will develop the technologies. The technology developers who have traditionally filled such a need in the past face similar resource limitations and problems. The problem is exacerbated by the fact that overseas competitors supported by their governments continue to pursue technology development.

While the primary technology base exists to meet the near-term challenges to the industry, substantial additional work must be done if the industry is to develop cost-effective solutions and remain competitive. It seems clear that despite lower profit margins

and diversion of cash flows, individual members of the industry will continue to pursue R&D with their remaining limited resources. There is an interest in leveraging these scarce resources through a limited collaborative program that focuses on common problems and/or precompetitive R&D areas that could benefit all, e.g., environmental R&D. In addition, the industry is interested in accessing and utilizing unique skills and expertise in the National Laboratories to pursue R&D in competitive areas on an individual basis or through formation of small consortia. This is underscored by the data presented in a later section describing ongoing National Laboratory R&D.

Establishment of an Industry/DOE (government) collaborative R&D program would represent a major cultural change for the industry. A prime characterization of the industry has been its independence - both collectively and individually. Competition between industry members has been severe as each has sought competitive advantages. A key contributing factor to achieving competitive advantages has been technological innovation. A collaborative program between the refinery industry and the DOE, however, would be compatible with the present administration's objectives/policies to help U.S. industry to remain competitive in the fiercely competitive international arena and minimize energy utilization and cost impacts on the U.S. economy.

Purpose of the Workshop on the Refinery of the Future

The National Petroleum Refiners Association and Argonne National Laboratory sponsored this workshop on behalf of the U.S. Department of Energy (DOE), for the purpose of soliciting comments from the petroleum-refining and petrochemical industries on their future direction and R&D needs. The workshop was designed to allow industry to express its views on a number of key issues, e.g.: 1) key market and regulatory factors/drives that are likely to cause significant change in refining petrochemical practices, 2) a vision of the "refinery of the future" beyond the year 2000, 3) specific changes in refinery/petrochemical technology that can be expected or that will be required, and 4) the types of research and development that will be required to assist the industry in making a cost-effective transition to the future. The information derived from the workshop will assist DOE in completing its assessment of industry's interest in and the need for establishing a collaborative research and development program with DOE.

WORKSHOP AGENDA

Day 1

8:30-8:45	Welcome and Opening Remarks *Terrence Higgins*, Technical Director, NPRA *C. Kyle Simpson*, Exec.Asst to the Deputy Secretary, DOE
8:45-9:20	DOE - Refinery Industry Interactions *Daniel Wiley*, Office of Industrial Technologies, Energy Efficiency and Renewable Energy, DOE
8:20-9:45	Conduct of Workshop *Michael Petrick*, Argonne National Laboratory
9:45-10:15	Plenary Session on Industry Vision of Refinery of the Future (ROF) *Bruce Burke*, Chem Systems
10:15-10:25	Organization of Breakout Sessions on Vision of ROF *Bruce Burke*, Chem. Systems

Session	Facilitator
Government Regulation	*Terrence Higgins*, NPRA
Market Forces	*Bruce Burke*, Chem Systems
Off-Shore Competition	*Gary Kohler*, EXXON
Feed Stocks	*Douglas Rundell*, AMOCO & *Linda Schilling*, DOE

10:25-10:40	Coffee Break
10:40-12:00	Break-Out Sessions on Vision of ROF
12::00-1:00	Group Lunch
1:00-2::30	Reconvene Break-Out Sessions on Vision of ROF
2:30-3:45	Invited talk: EPA-AMOCO Yorktown Project: Lessons Learned & Future Steps *Steve Harper*, Senior Policy Analyst, EPA *Ronald Schmitt*, AMOCO
3:45-4:00	Coffee Break
4:00-5:00	Wrap-Up Plenary Session on Vision of the Refinery of the Future (Presentation and Integration of Group Findings) *Bruce Burke*, Chem Systems and Break-Out Group Facilitators
5:00-5:20	Plenary Session on Industry R&D Needs/Opportunities *Francis Dawson*, California Synfuels
5:20-5:30	Organization of Break-Out Sessions on Industry R&D Needs/Opportunities *Francis Dawson*, California Synfuels

Day 2

8:00-10:45	Break-Out Sessions on Industry R&D Needs/Opportunities

Session	Facilitator
Environmental R&D	*Arnie Schaffer*, Phillips 66
Enabling Technology	*W.J. (Bill) Hillier*, The M.W. Kellogg Co.
Process Development/ Improvement	*Ronnie Jackson*, Lion Oil Co.
Fundamental Science/ Basic Research	*Arthur Suchanek*, Criterion Catalyst Co.

10:45-11:00	Coffee Break
11:00-12:00	Plenary Session on Relevant DOE/National Laboratory Capabilities *Bill Schertz*, Argonne National Laboratory
12:00-1:15	Group Lunch
1:15-2:15	Wrap Up Plenary Session on R&D Needs (Presentation and Integration of Group Findings) *Francis Dawson* and Breakout Group Facilitators
2:15-2:45	Plenary Session on Other Issues Relevant to Establishing a DOE-Industry Collaborative Program *Skip Robinson*, BP America
2:45-3:00	Wrap-Up/Closing Remarks *Dan Wiley*, OIT-EE-DOE

OPENING REMARKS

Speaker: **Kyle Simpson**
(Executive Assistant to the Deputy Secretary, U.S. DOE)

SUMMARY OF OPENING REMARKS by C. Kyle Simpson Exec. Asst. to Deputy Secretary, DOE

The Department of Energy is undergoing a transformation; a cultural change is occurring. Personnel with a background in industry are being brought in to help DOE change. Administrative changes are being made to improve efficiency and function. The new staff additions are acting as industry advocates and advising DOE how it can spend its money more efficiently. DOE must help industry respond to the changing world marketplace. The mission of DOE is also changing. The agency is downsizing weapons production and increasing emphasis on the energy side. It is seeking to refocus its mission to address environmental problems. Energy R&D program emphasis and orientation is shifting more to gas and oil, and we are focusing more R&D on waste minimization and pollution prevention. The department is seeking advice from the industry as it shifts its mission to focus on environmental issues. The department is forming R&D partnerships with strategic industries — those that have the potential to create new jobs and add to the nation GDP, are critical to national security, and are technology driven. Examples of industries that government has formed partnerships with include the auto, aerospace, semiconductor, and environmental technology industries.

A recent EIA study has shown that end-use consumption of petroleum products will increase from 33.7 quads in 1992 to ~ 42 quads in the year 2010 (your draft Vision of the Refinery of the Future document indicated a level of 38 quads). The issue is, who will refine this oil; will it be done here or overseas? We want it to be refined in the U.S. We recognize that your industry faces a major challenge as a result of the environmental regulations that it must comply with and that the costs are very large; this was clearly outlined in the NPC study. We believe that these costs can be controlled. This potential was illustrated by the Amoco Study, which showed that with the traditional command and control approach the cost of compliance would be $2100/ton of pollutant; with the coordinated management approach the cost would decrease to $500/ton. DOE has a commitment from EPA to work together to modify its regulatory regime to allow regulatory compliance more in line with the Amoco Yorktown model.

We view the refinery of the future as a domestic industry that will create jobs and that will be environmentally benign. We view the industry as a strategic industry. Our perception is that you need help. If this is true, we need to hear from you. Other strategic industries are receiving aid. They come to us and speak with one voice. We recognize that the oil industry, however, is fractured and diverse. We also recognize that part of the problem is dealing with the administration and Congress. We need a clear message from you as to what you want and what will work. Tell us what needs to be done; this is the message that should come from the conference.

DOE - INDUSTRY INTERACTIONS

Speaker: **Daniel Wiley**
Office of Industrial Technologies
Energy Efficiency and Renewable Energy
Department of Energy

DOE - INDUSTRY INTERACTIONS

DAN WILEY
OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY
OFFICE OF INDUSTRIAL TECHNOLOGIES

THANK YOU, KYLE, FOR SETTING THE STAGE FOR THIS WORKSHOP. I WOULD ALSO LIKE TO THANK THE NATIONAL PETROLEUM REFINERS ASSOCIATION AND ARGONNE NATIONAL LABORATORY, WHO HAVE WORKED DILIGENTLY TO HOST THIS WORKSHOP FOR DOE. AND LASTLY, I WOULD LIKE TO THANK YOU, THE PARTICIPANTS IN THIS WORKSHOP, FOR YOUR COMMITMENT OF TIME TO THIS ENDEAVOR.

THE OUTLINE OF MY TALK ON **DOE - INDUSTRY INTERACTIONS** IS AS FOLLOWS:

DOE - INDUSTRY INTERACTIONS

- REASON FOR DOE INVOLVEMENT
- ORGANIZATIONS CONTACTED
- DEVELOPMENT OF INDUSTRY "VISION", STAKEHOLDER INVOLVEMENT
- ACCOMPLISHMENTS, FINDINGS, SUGGESTED DIRECTIONS
- EXPECTATIONS, WHERE DO WE GO FROM HERE?

WHY IS THE DEPARTMENT OF ENERGY MAKING THIS EFFORT TO SOLICIT YOUR VIEWS ON THE REFINING INDUSTRY'S FUTURE "VISION"?

THERE ARE A NUMBER OF REASONS, STARTING WITH THE DOE MISSION ITSELF AS THE FIRST REASON:

U.S. DEPARTMENT OF ENERGY
MISSION

THE DEPARTMENT OF ENERGY IS ENTRUSTED TO CONTRIBUTE TO THE WELFARE OF THE NATION BY PROVIDING THE SCIENTIFIC FOUNDATION, TECHNOLOGY, POLICY AND INSTITUTIONAL LEADERSHIP NECESSARY TO ACHIEVE EFFICIENCY IN ENERGY USE, DIVERSITY IN ENERGY SOURCES, A MORE PRODUCTIVE AND COMPETITIVE ECONOMY, IMPROVED ENVIRONMENTAL QUALITY, AND A SECURE NATIONAL DEFENSE.

THE SECOND REASON IS THE REPORT ON U.S. PETROLEUM REFINING - MEETING REQUIREMENTS FOR CLEANER FUELS AND REFINERIES, BY THE NATIONAL PETROLEUM COUNCIL, AUGUST, 1993. THIS REPORT WAS PREPARED IN RESPONSE TO A REQUEST FROM THE SECRETARY OF ENERGY AND PRESENTS A STARK YET COMPREHENSIVE PORTRAYAL OF THE U.S. PETROLEUM REFINING INDUSTRY OVER THE NEXT TWENTY YEARS. THE REPORT COMPRISES SIX VOLUMES AND AN EXECUTIVE SUMMARY (3,190 PAGES).

NATIONAL PETROLEUM COUNCIL STUDY

- PROJECTED U.S. REFINING CAPITAL EXPENDITURES OF $37 BILLION IN THE 1991-2000 PERIOD FOR PRODUCT QUALITY AND STATIONARY SOURCE REGULATORY COMPLIANCE
- MANY REFINERIES UNDERUTILIZED IN 1990s, INADEQUATE MARGINS
- LARGE FINANCIAL/LEGAL BARRIERS TO SHUTTING DOWN REFINERIES
- U.S. INDUSTRY COMPETING IN GLOBAL MARKETPLACE
- FOREIGN REFINED PRODUCTS HAVE LOWER EMBEDDED ENVIRONMENTAL COSTS

RECOMMENDATIONS

- COST-EFFECTIVE REFORMULATED GASOLINE REGULATIONS THAT ARE FULLY COMPATIBLE WITH THE EXISTING DISTRIBUTION SYSTEM
- CONSTRUCTIVE PARTNERSHIP PROCESS INVOLVING INTERESTED STAKEHOLDERS TO CREATE COST-EFFECTIVE SOLUTIONS TO SOCIETAL CONCERNS RELATED TO THE INDUSTRY
- RECOGNITION BY POLICY MAKERS THAT THE COSTS OF REGULATION WILL ULTIMATELY BE REFLECTED IN THE MARKETPLACE

COPY AVAILABLE: NPC PUBLICATIONS, 1625 K STREET, WASHINGTON, DC 20006

THE THIRD REASON IS THE DOMESTIC NATURAL GAS AND OIL INITIATIVE, ISSUED DECEMBER 9, 1993. THIS PRESIDENTIAL INITIATIVE IS AIMED AT BOOSTING MARKETS FOR DOMESTIC NATURAL GAS AND OIL WHILE DEVELOPING A LONG-TERM STRATEGY TO LESSEN AMERICA'S DEPENDENCE ON FOREIGN OIL. THE INITIATIVE IS A KEY ELEMENT IN THE DEVELOPMENT OF AN INCLUSIVE ENERGY POLICY THAT WILL PROMOTE ECONOMIC AND NATIONAL SECURITY, ENERGY DIVERSITY AND ENVIRONMENTAL PROTECTION

THE DOMESTIC NATURAL GAS AND OIL INITIATIVE
DECEMBER 9, 1993

"The Clinton/Gore energy policy stresses developing new ways to use the energy sources we already have--including domestic gas and oil, conservation, efficiency, and exploring alternative and renewable sources."

Strategic Activity I

Increase domestic natural gas and oil production and environmental protection by advancing and disseminating new exploration, production, and refining technologies.

Strategic Activity II

Stimulate markets for natural gas and natural-gas-derived products, including their use as substitutes for imported oil where feasible.

Strategic Activity III

Ensure cost-effective environmental protection by streamlining and improving government communication, decision making, and regulation.

COPY AVAILABLE: DOE OFFICE OF PUBLIC AFFAIRS 202/586-5806

The possibilities for industry-government collaborations are many. The next two slides provide funding levels for federal agency industrial technology programs. These dollars reflect program areas that provide collaborative opportunities for industrial participation. The first slide addresses federal agencies. The second slide provides a more detailed breakdown for the U.S. Department of Energy. A report covering this information will be available in the near future, and will provide a list of contacts for each program area.

Federal Agency Industrial Technology Programs

Agency	FY 93 ($ millions)	FY94 ($ millions)
Agriculture	59.8	73.2
Commerce	143.1	296.8
Defense	3,683.0	4,846.0
Energy	2,043.3	2,622.1
Institutes of Health	100.2	100.9
Interior	98.0	97.1
Transportation	346.8	399.6
Environmental Protection	0	36.0
NASA	1,210.9	1,316.1
NSF	636.8	673.9
Total	$8,321.9	$10,456.7

Department of Energy Industrially Relevant Programs

Program	FY 93 ($ millions)	FY94 ($ millions)
Clean Coal Demonstration	0.0	225.0
Fossil Energy	418.4	430.7
Energy Efficiency R&D	345.3	444.0
Energy Efficiency Grants	330.8	325.0
Renewable Energy	250.9	323.1
Nuclear Energy	199.0	311.2
ERWM	336.9	295.9
Energy Research	9.0	39.2
Defense Programs	153.0	228.0
Total	$2,043.3	$2,622.1

COMPREHENSIVE PROGRAM PLANS ARE BEING PREPARED WITHIN DOE FOR A NUMBER OF ENERGY-INTENSIVE INDUSTRIES TO BETTER FOCUS FEDERAL TECHNOLOGY R&D ACTIVITIES. THE "INDUSTRY OF THE FUTURE" CONCEPT HAS BEEN OF GREAT INTEREST TO INDUSTRY, AND CONVEYS THE STRATEGIC AND GLOBAL NATURE OF OUR PROGRAMS. INDUSTRY, IN TURN, HAS SHOWN A VERY POSITIVE INTEREST IN PARTICIPATING IN THE DEVELOPMENT OF THESE COMPREHENSIVE PLANS. ESSENTIAL COMPONENTS REQUIRED FOR THE DEVELOPMENT OF THESE PLANS INCLUDE:

VISIONS: INDUSTRIES OF THE FUTURE
ELEMENTS FOR ANALYSIS

- IN-DEPTH CHARACTERIZATION OF THE INDUSTRY TODAY
- IDENTIFICATION OF THE KEY DRIVERS IMPACTING EACH INDUSTRY
- DEVELOPMENT OF ONE OR MORE SCENARIOS DEPICTING THE FUTURE VISION FOR EACH INDUSTRY
- DEVELOPMENT OF THE TECHNOLOGY NEEDS TO FULFILL EACH INDUSTRY'S VISION

DURING 1993 WE DEVELOPED AN EXTENSIVE DIALOGUE WITH THE PETROLEUM REFINING INDUSTRY. THE APPROACH TAKEN TO DEVELOP STAKE HOLDER INVOLVEMENT IS OUTLINED HERE. WE DID OUR HOME WORK AND PREPARED STRAWMAN DOCUMENTS THAT PRESENTED A VISION OF THE REFINERY OF THE FUTURE AND OUTLINED AN R&D PROGRAM PLAN. THESE DOCUMENTS WERE PREPARED TO ELICIT INDUSTRY COMMENTS AND RESPONSES. A NUMBER OF SOURCES WERE USED IN DEVELOPING THESE "STRAWMEN," NAMELY ARGONNE NATIONAL LABORATORY AND CONSULTANTS KNOWLEDGEABLE IN THE REFINERY INDUSTRY.

APPROACH TO STAKEHOLDER INVOLVEMENT

I. DO OUR HOMEWORK

PREPARE STRAWMAN DOCUMENTS

IDENTIFY OUR CUSTOMER'S NEEDS

SPONSOR PUBLIC WORKSHOPS FOR STAKEHOLDERS

II. FACILITATE DEVELOPMENT OF INDUSTRY VISION AND R&D PLAN

VALUABLE STAKEHOLDER INPUT HAS BEEN OBTAINED BY SEEKING INDUSTRY REACTIONS TO THESE PLANS THROUGH ONE-ON-ONE MEETINGS WITH REFINERY INDUSTRY ORGANIZATIONS MOST OF WHICH ARE PRESENT TODAY. THOSE WE MET WITH ARE NOTED ON THE NEXT SLIDE.

LIST OF REFINING INDUSTRY ORGANIZATIONS CONTACTED

ABB Lummus Crest, Inc.
Amoco
ARCO Engineering and Technology
Ashland Petroleum Company
BP America
Catalytica
Chevron Research and Technology
ENSR Consulting and Engineering
Exxon Research and Engineering
The M.W. Kellogg Company
Lion Oil Company
Mobil Research and Development Corp.
Phillips 66 Company
Santa Fe Energy Resources, Inc.
Texaco, Inc.
Tosco Refining Company
UNOCAL Process Technology & Licensing
UOP

California Independent Producers Association
Independent Oil Producers Association
Western States Petroleum Association
National Petroleum Refiners Association
Petroleum Environmental Research Forum

I WOULD LIKE NOW TO TAKE A FEW MOMENTS TO DISCUSS THE MEETINGS THAT WE HELD WITH THE REFINING INDUSTRY, WHAT OUR PURPOSE WAS, AND RESULTS OF THE DISCUSSIONS.

MEETING OBJECTIVES
REFINERY OF THE FUTURE DISCUSSIONS
WITH THE REFINING INDUSTRY

- IS THERE NEED FOR FEDERAL SUPPORT FOR R&D?
- IS THERE INDUSTRY INTEREST IN COST SHARED COLLABORATIVE PROGRAM?
- WHAT ARE INDUSTRY R&D NEEDS - NEAR TO FAR-TERM?
- WHAT TYPES OF R&D ARE APPROPRIATE FOR GOVERNMENT SUPPORT?
- IS THERE WILLINGNESS TO COLLABORATE WITH OTHER COMPANIES?
- WHAT ARE THEIR REQUIREMENTS FOR DISPOSITION OF INTELLECTUAL PROPERTY?
- ARE THERE INDUSTRY ORGANIZATIONS WITH CAPABILITY TO PROVIDE INPUT TO PROGRAM, OR LEAD SUCH A PROGRAM EFFORT WITH DOE?

PRELIMINARY FINDINGS

- FEDERAL SUPPORT DESIRED IN TARGETED AREAS
- STRONG INDUSTRY INTEREST IN LEVERAGING R&D FUNDS
- 50-90% OF INDUSTRY'S CASH FLOW REQUIRED TO MEET ENVIRONMENTAL REQUIREMENTS IN THE U.S., LESS FUNDS AVAILABLE FOR R&D
- INDUSTRY UNCERTAIN WHO WILL PROVIDE TECHNOLOGY IMPROVEMENTS
- INDUSTRY SEEKS TECHNOLOGY OPTIONS TO MINIMIZE ECONOMIC IMPACT ON INDUSTRY
- REFINING MOVING OFFSHORE UNLESS CORRECTIVE ACTIONS ARE IMPLEMENTED

TECHNOLOGY CHALLENGES

- **UNANIMOUS SUPPORT FOR COLLABORATIVE PROGRAM THAT FOCUSES ON ENVIRONMENTAL ISSUES**
  - Common problems
  - Scientific basis for regulations
  - Non-level playing field
- **STRONG SUPPORT FOR PRE-COMPETITIVE R&D**
  - Enabling technology development
  - Basic research
  - "Breakthru" processes/technologies
- **LIMITED SUPPORT FOR INCREMENTAL PROCESS IMPROVEMENT, DEVELOPMENT, DEMONSTRATION, AND DEPLOYMENT**
- **LITTLE SUPPORT FOR LONG-RANGE ALTERNATIVE FEEDSTOCK DEVELOPMENT**

NATIONAL INTEREST IN NATIONAL LABORATORY CAPABILITY

- RECOGNIZE CORE COMPETENCY IN SPECIFIC AREAS
- DESIRE EASY ACCESS TO THE NATIONAL LABORATORY SYSTEM
- NEED TO COORDINATE LABORATORY PARTICIPATION
- ACCESS UNIQUE CAPABILITIES AND EXPERTISE TO SUPPORT:
  - INDUSTRY WIDE COLLABORATIVE PROGRAMS IN NONCOMPETITIVE R&D AREAS
  - INDIVIDUAL COMPANIES PURSUING R&D IN COMPETITIVE AREAS

SUGGESTED DIRECTIONS FROM INDUSTRY

- EFFECTIVE PROGRAM REQUIRES RE-FOCUSING AVAILABLE PROGRAM FUNDS TO SUPPORT INDUSTRY'S HIGHEST PRIORITY NEEDS
- INDUSTRY IS INTERESTED IN ESTABLISHING A PARTNERSHIP WITH DOE
- STRONG INDUSTRY SUPPORT FOR DEVELOPMENT OF TECHNOLOGIES TO MEET ENVIRONMENTAL REQUIREMENTS
- STRONG INDUSTRY SUPPORT FOR ENVIRONMENTAL COOPERATIVE MANAGEMENT (E.G., AMOCO-YORKTOWN EXPERIENCE)

WHERE DO WE GO FROM HERE?

- COMPLETE INDUSTRY VISION DOCUMENT AND R&D PLAN
- FACILITATE INDUSTRY ACCESSIBILITY TO NATIONAL LABORATORY
- INCREASE INVOLVEMENT WITH OTHER FEDERAL AGENCIES: E.G., WORKING GROUP TO REVIEW NPC FINDINGS WITH EPA
- ENCOURAGE REFINING INDUSTRY TO ASSUME ROLE FOR THE REFINERY OF THE FUTURE INITIATIVE
- ESTABLISH MECHANISM FOR AN ON-GOING DIALOGUE WITH THE REFINING INDUSTRY

It is now my pleasure to introduce Dr. Mike Petrick, Argonne National Laboratory, who has been assisting DOE in the development of this Refinery of the Future initiative. Mike will explain how the workshop is structured, and your role in it. Unless there are any procedural questions at this time, I will turn the meeting over to Mike.

CONDUCT OF THE WORKSHOP

ON THE

REFINERY OF THE FUTURE

Speaker: **Michael Petrick**
(Argonne National Laboratory)

Workshop Organization

- Specific objectives
- Agenda/structure
- Workshop documents
  - Vision of Refinery of the Future
  - draft of R&D plan
- Workshop operation and logistics
- Desired outcomes

Workshop Objectives

- Present a forum for all interested parties to express their views
- Develop an industry Vision of the Refinery of the Future
- Identify and discuss industry R&D needs that are compatible with the Vision of the Future
- Introduce industry to National Laboratory capabilities
- Discuss next steps, if any, that should be taken

Workshop Structure (Agenda)

- DOE-industry interactions to date
- Plenary/breakout sessions to define the Vision of Refinery of the Future
- Invited speaker from EPA
- Plenary/breakout sessions on R&D needs/opportunities
- Introduction to national laboratory capabilities
- An open session to address other relevant issues
- Where do we go from here

Proposed Method of Operation

- Follow OIT Industry of the Future R&D approach for Program definition
- Use industry participants as facilitators for plenary and breakout sessions
- Use materials provided to stimulate/facilitate discussions
- Initial plenary session for each area
  - review of materials provided
  - general discussion of issues/questions to be addressed
  - charge to the breakout sessions

Proposed Method of Operation (cont.)

- Breakout sessions discuss key issues/questions impacting definitions of Vision of ROF and R&D needs
  - develop industry views
  - draw conclusions and prioritize where possible

- Wrap up plenary session for each area
  - summary presentation and discussion of findings
  - conclusions

- Plenary session on DOE capabilities
  - presentation of national laboratory capabilities
  - panel discussion with laboratory representatives

- Plenary session on other issues

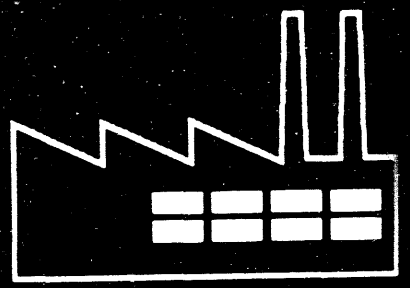
OIT Industry of the Future Progra

Drivers (e.g. [illegible] market, regulatory)

Industry Today

Characteristics:

-
-
-



Vision: Industry o[illegible] the Future

Characteristics:

-
-
-

Technology Nee[illegible]

Workshop Materials

- Draft of a Vision of the Refinery of the Future
- Draft of a Program Plan
- Supporting materials – discussion/issue papers, questionaires, etc. – for breakout sessions

Draft Report on Vision of Refinery of Future

- Summarizes past trends/drivers that impacted industry
- Identifies current and future drivers that can be expected to impact industry
- Projects changes in key refinery industry characteristics
- Presents a Vision of the Refinery of the Future
- Identifies general R&D needs that evolve from expected changes
- Reflects feedback from discussions with 17 industry companies

Draft Report on R&D Needs of Refinery Industry

- Based on needs/opportunities identified in Vision of Refinery of Future study

- Report prepared by ANL to facilitate interaction with industry
  - inputs from consultants, Chem. Systems
  - incorporates feedback from meetings with industry
  - made purposefully broad in scope to address potential needs across the industry
  - reflects diversity of industry views and DOE perceptions of nation's and industry's needs

Desired Outcomes

- An Industry Vision of the Refinery of the Future
  - can modify existing document
  - develop alternative vision document
- A deliniation of R&D needs and priorities
- A clear indication as to whether a collaborative DOE-industry program is needed and/or should be pursued.

PLENARY SESSION

ON

VISION OF THE REFINERY

OF THE FUTURE (ROF)

SESSION CHAIRMAN: Bruce Burke
(Chem Systems)

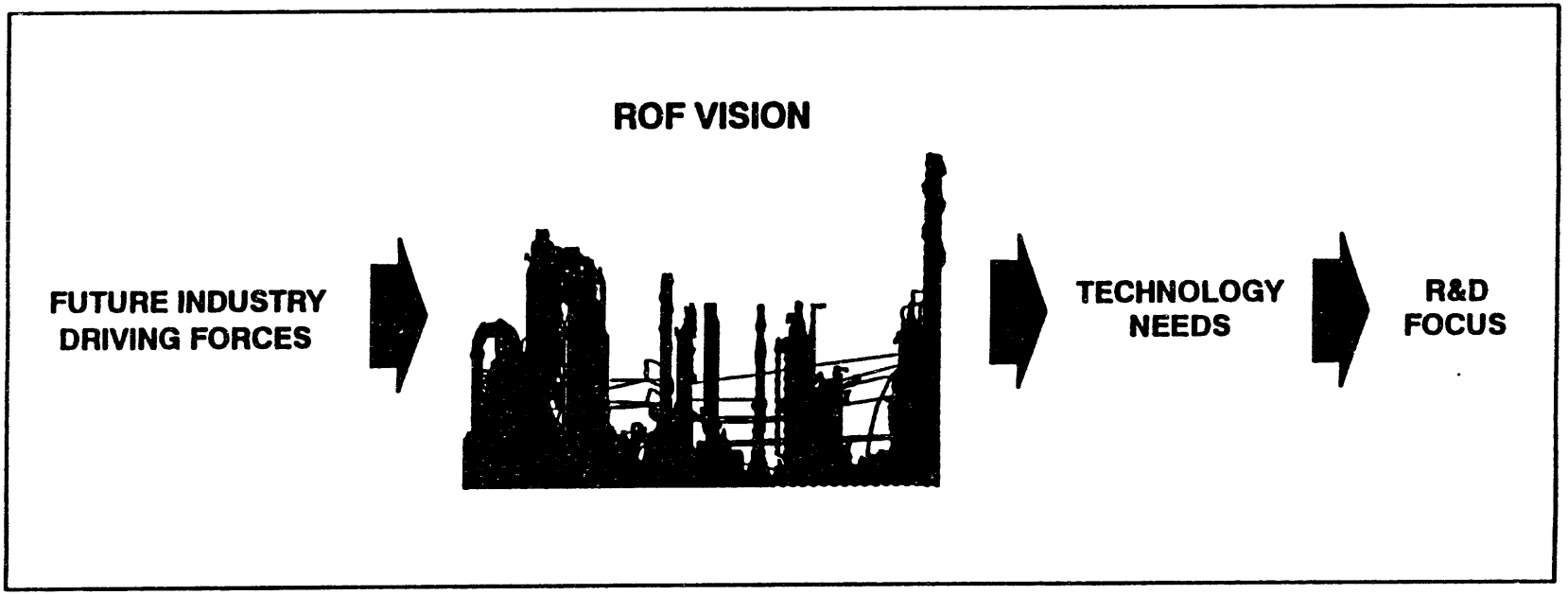
PRESENTATION OBJECTIVES

- BRIEF OVERVIEW OF VISION OF REFINERY OF THE FUTURE
  - BASED ON SOURCE DOCUMENT PROVIDED TO WORKSHOP PARTICIPANTS
    - * REFLECTS EXTENSIVE REVIEW/COMMENTS OBTAINED FROM IN-DEPTH MEETINGS WITH 17 INDUSTRY COMPANIES
    - * BASE PROJECTIONS BY CHEM SYSTEMS
- OUTLINE CHARGE TO BREAKOUT SESSIONS TO ACHIEVE WORKSHOP OBJECTIVE: REACH CONSENSUS ON ROF VISION
  - REVIEW KEY ASSUMPTIONS AND CONCLUSIONS ON KEY ISSUES AND PROJECTIONS
    - * REACH CONSENSUS WHERE POSSIBLE
    - * IDENTIFY AREAS WHERE STRONG DIVERGENT VIEWS EXIST

OVERVIEW OF

VISION OF REFINERY OF THE FUTURE

The resultant vision of the refinery of the future and associated technology needs will provide a framework to target long-term R&D requirements



Industry Driving Forces

Industry development has historically reflected a mix of market and regulatory forces

- International linkage
- Product market development
- Regulations and public policy

SUMMARY OF KEY PAST DRIVING FORCES THAT HAVE IMPACTED THE INDUSTRY DURING PAST YEARS

KEY PAST INDUSTRY DRIVING FORCES/TRENDS

- REGULATORY PROGRAMS HAVE SHAPED THE REFINERY INDUSTRY
  - PRICE CONTROLS
  - SMALL REFINER BIAS
  - CAFE STANDARDS
  - LEAD PHASE DOWN
  - PRICE DECONTROL
  - RVP REDUCTIONS
- INTERNATIONAL EVENTS HAVE SEVERELY IMPACTED U.S. CRUDE OIL PRICE
  - ARAB/ISRAELI WAR, EMBARGO
  - IRANIAN REVOLUTION
  - OPEC PRICE WAR
  - CURRENT MIDEAST CONFLICT
- PRICE VOLATILITY AND REGULATORY FIAT HAVE SHAPED MACRO ENERGY USE
  - TOTAL ENERGY AND PETROLEUM USE HAS DECLINED
  - COAL AND NUCLEAR MAJOR BENEFICIARIES OF ENERGY USE TRENDS
    - * PETROLEUM USE HAS DECLINED FROM 46.9 TO 39.8% FROM 1973 TO 1993

KEY PAST INDUSTRY DRIVING FORCES/TRENDS (CONT'D)

- MARKETS TRENDS ARE WELL ESTABLISHED TOWARD LIGHT CLEAN PRODUCTS
  - RESIDUAL FUEL USAGE/PRODUCTION TREND IS DOWNWARD DUE TO LOSS OF BASELOAD POWER GENERATION AND ENVIRONMENTAL PRESSURES
  - GASOLINE'S DOMINANCE HAS DECLINED
    - * GASOLINE/DISTILLATE PRODUCTION IS DECLINING; CURRENTLY AT 1.62
- INDUSTRY STRUCTURE HAS CHANGED DRAMATICALLY
  - NUMBER OF OPERATING REFINERIES HAVE DECLINED FROM A PEAK OF 320 TO 170
  - AVERAGE REFINERY SIZE HAS INCREASED FROM 35 TO 88 MBPD
- CRUDE OIL QUALITY HAS DECLINED
  - WEIGHT PERCENT SULFUR IN CRUDE HAS INCREASED FROM .88 TO 1.13% OVER THE PERIOD 1981 - 1993
  - AVERAGE CRUDE GRAVITY FROM 34 TO 31.2° API

FUTURE INDUSTRY DRIVING FORCES THAT WILL SHAPE THE REFINERY OF THE FUTURE

Future Industry Driving Forces

Regulatory developments will have the greatest impact on the industry

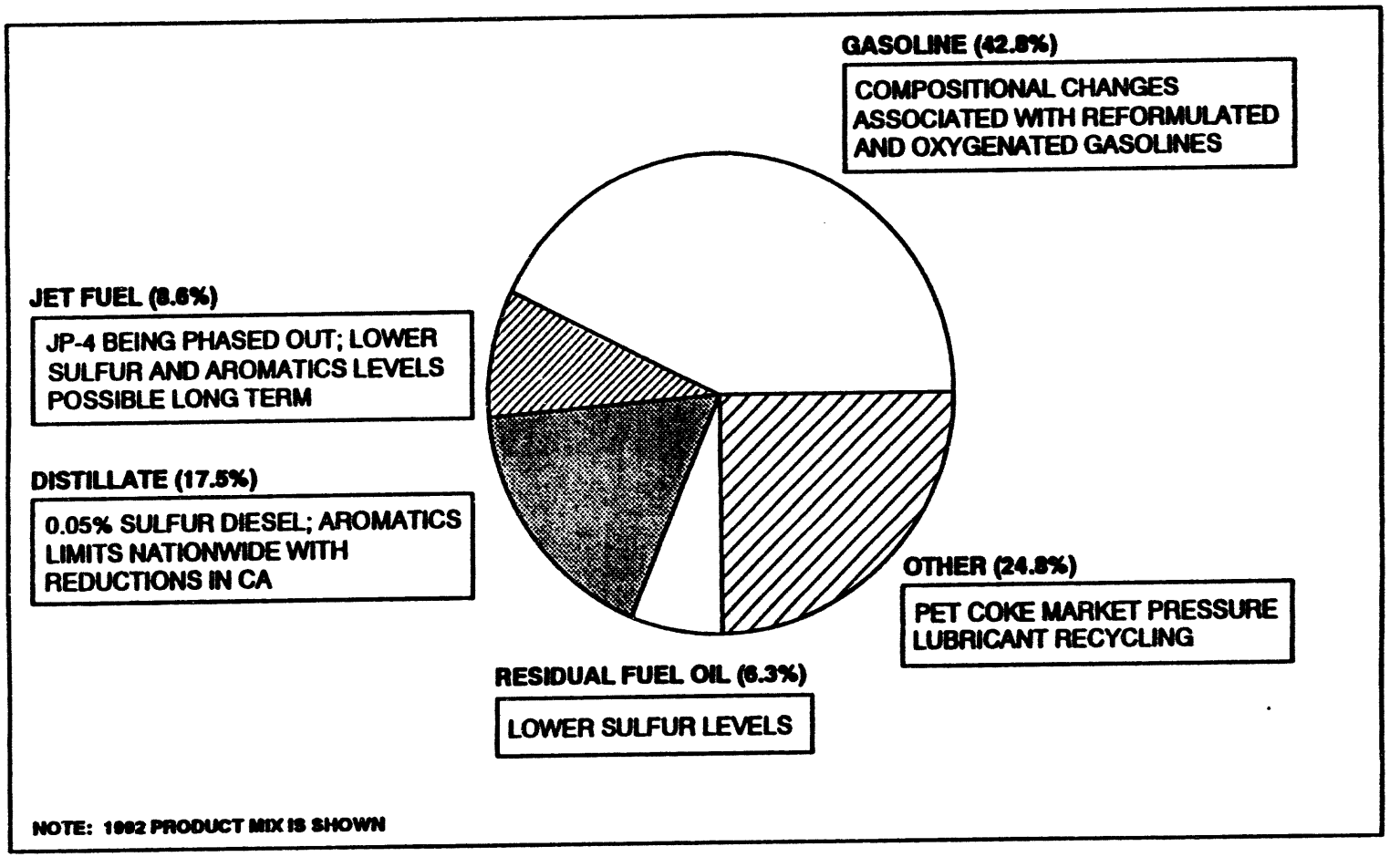
- Federal and state initiatives
- Market forces secondary
- International links growing, but secondary

Regulatory developments will be environmentally driven

KEY DATES FOR FUEL-RELATED CAA MOBIL SOURCES PROVISIONS										
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Fuel volatility	5/92									
Air toxics	5/92 study			5/95 standards						
Oxygenated gasoline	Phase I 11/92								Phase II 2000	
Diesel fuel sulfur content		10/93							Phase II	
Reformulated gasoline				Phase I 1/95					Phase II 2000	
Clean-fuel vehicles California pilot test program Centrally fueled fleets					Phase I MY96		MY98			Phase II MY01

Future Industry Driving Forces

Mandatory changes in product quality requirements will impact all major products



Future Industry Driving Forces

Other major legislation is expected to affect the demand for refined products:

- The Energy Policy Act of 1992 mandated purchases of alternatively fueled vehicles and provided tax incentives for converting vehicles to alternative fuels

- The Corporate Average Fleet Efficiency standards established in 1978 mandated increases in the minimum fuel efficiency standards for new vehicles through 1991. Further increases in the standards have been proposed in the past and may be enacted in the future

- Title IV of the CAA incorporating provisions to reduce SOx and NOx emissions from power plants and industry will also impact the refining industry. These provisions are expected to contribute to the continued decline in high-sulfur fuel oil demand and to increase low-sulfur fuel oil demand

- Growing control of stationary emissions

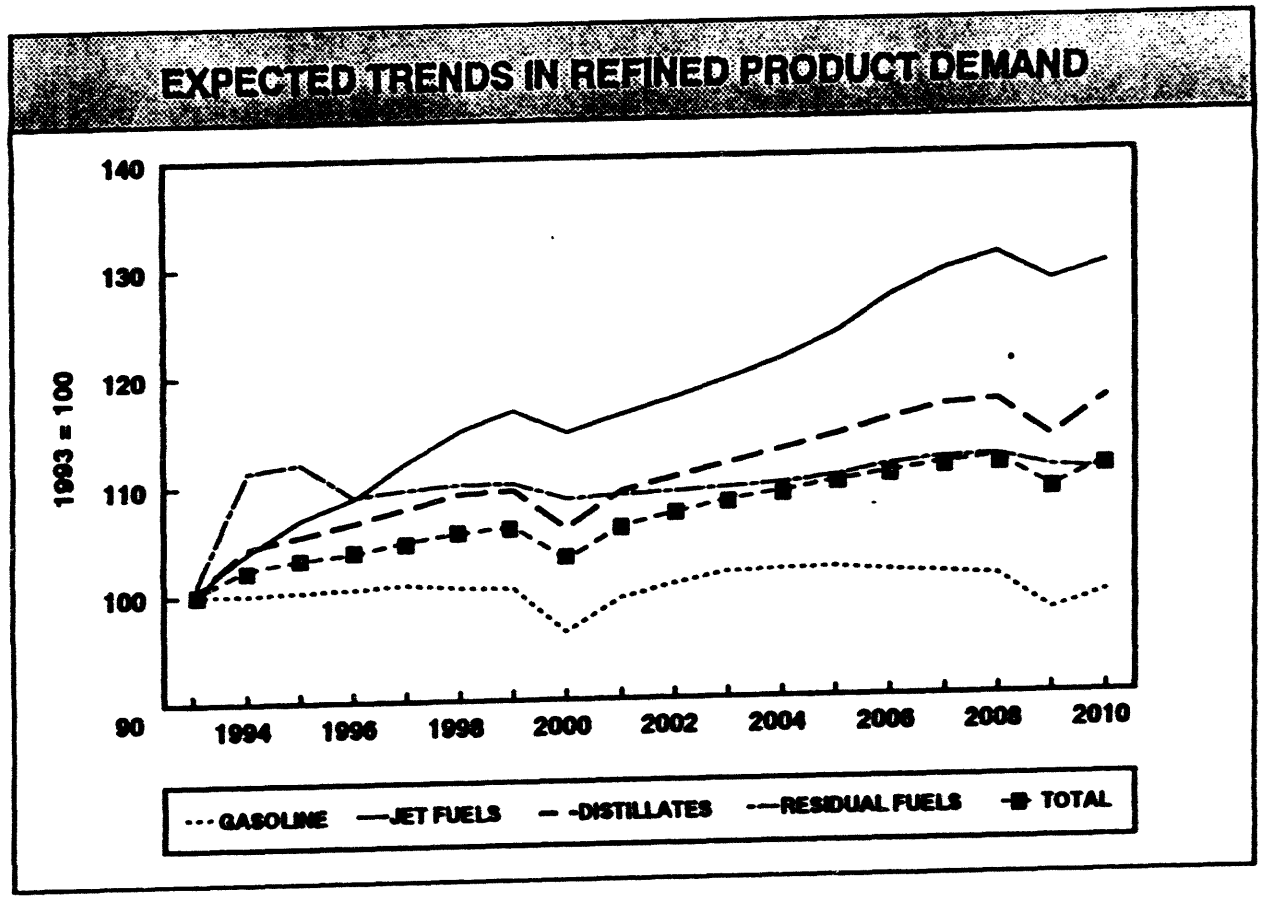
Future Industry Driving Forces

NPC estimates future regulatory burden to be twice recent levels

- $152 billion over next 20 years[1]
- Annual burden to increase over time
- Expenditures do not directly enhance revenues
- Expected shift from air --> wastewater + solid waste

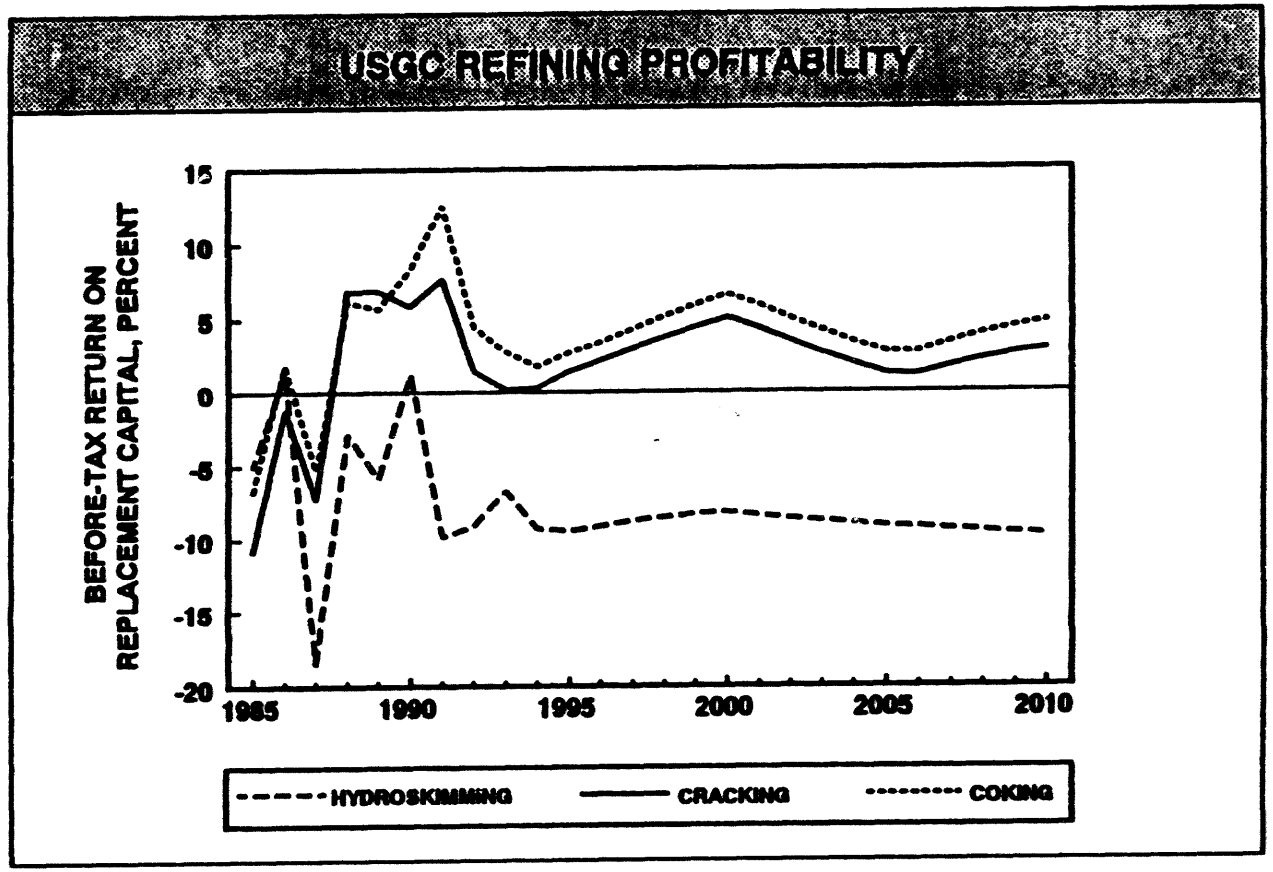
[1] Stationary source environmental facility costs

Maturity of domestic market will limit industry growth potential



- GDP growth of 2.5 percent average
- Total petroleum demand growth of 0.6 percent

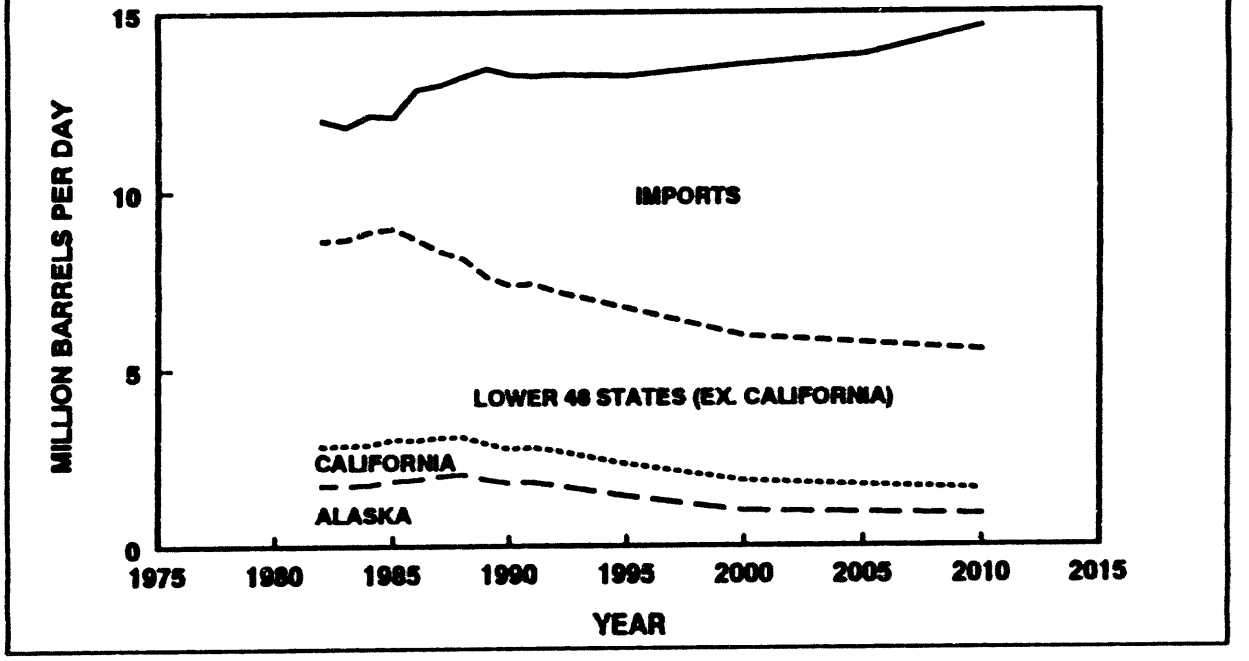
Future industry profitability will not support grassroots expansions



- Ability to "pass-on" regulatory costs is a major issue
- Regulatory/economic constraints will limit capacity expansions

Crude oil will remain the primary refining feedstock, though quality will continue to decline

U.S. CRUDE OIL SUPPLY



U.S. CRUDE SLATE COMPOSITE QUALITY, 1981-2010

	1981	1985	1990	1992	1995	2000	2010
Crude gravity, API	34.0	32.5	31.9	31.3	31.0	30.8	30.4
Crude sulfur, wt %	0.88	0.91	1.10	1.16	1.20	1.31	1.43

Future Industry Driving Forces

Refining yields will continue long-term trends

- Continued shift toward distillates
- Declining yield of residual fuel

VISION OF THE REFINERY OF THE FUTURE

Future industry structure will reflect strong competitive pressures

- Mature industry
- Rising cost structure
- Continued rationalization/restructuring
- Bias toward larger, more complex facilities
- Capital intensive
- Issue of cost pass-through: profitability

The ROF will evolve from current industry fundamentals

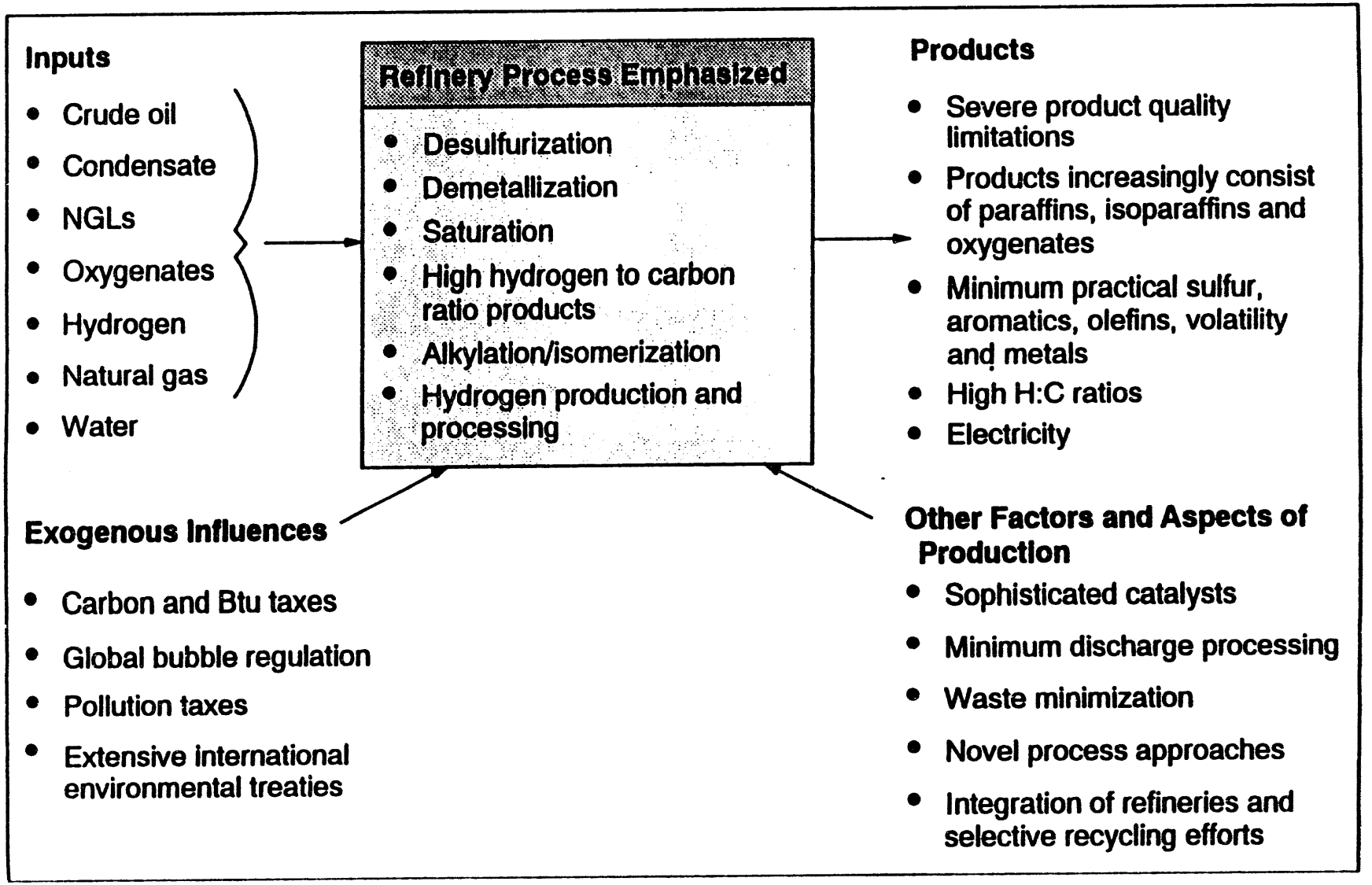
- Petroleum to remain primary feedstock
- Most existing processes will survive
- Better efficiency
- Better "accounting" capabilities and requirements
  - Process controls
  - Information systems
  - Testing
  - PSM
  - RFG certification
- Continued strong foreign links
  - Direct ownership
  - Rapid growth in crude oil imports
  - Less rapid growth in product imports

Refinery of the Future Vision

The ROF will be shaped by environmentally driven regulations

- Environmentally benign
  - Cradle-to-grave treating
- Poorer feedstock quality
- Better product quality and mix
  - H/C ratio
  - Molecular shaping/conversion
- Customized product compositions
- Stronger governmental oversight

Key elements of the Refinery of the Future vision are illustrated below



Refinery of the Future Vision

A positive working relationship between regulators and industry is needed to support the industry's future cost competitiveness

Representative Goals

- Develop a constructive relationship between the EPA and the refining industry that focuses on cost-effective, refinery-wide solutions to societal concerns
- Utilize sound scientific bases for all regulatory initiatives
- Foster a close working relationship between automobile manufacturers and oil companies, achieving environmental improvement by optimizing the fuel/engine "system" for both gasoline and diesel vehicles
- Develop regulations covering the remediation of contaminated soil and closed refinery sites that do not impose a high-cost burden on the refining industry
- Eliminate/limit regulatory uncertainty
- Promote a regulatory environment that allows refineries to compete as electricity producers

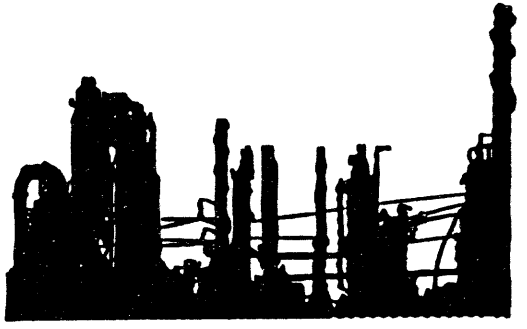
Refinery of the Future Vision

Environmental and advanced basic technologies and an improved knowledge of fuel/vehicle/air quality linkages are the industry's key technology needs

Future Industry Driving Forces

- Mature domestic product markets
- Growing environmental regulation
  - Product quality
  - Operations
- Continued use of traditional feedstocks
- Limited expansions/growing import exposures
- Lower quality crude oils
- Competitive/low profit environment

Refinery of the Future - Year 2000



- Environmentally benign
  - Air
  - Water
  - Solid wastes
- Tailored product compositions
- Computer control/monitoring
- Increased complexity/processing
- Energy efficient

Technology Needs

- Extend existing processes
  - Cost and waste reduction
  - Yields
  - Efficiency
- Basic technology advances
  - Catalysis by design
  - Separation sciences
  - Combustion sciences
- Research fuel/vehicle/air "system"

Supported by cooperative/scientific regulatory environment

CHARGE TO FACILITATORS FOR BREAKOUT SESSIONS

- SEEK TO OBTAIN PARTICIPANTS' VIEWS & COMMENTS ON THE ISSUES AND ASSUMPTIONS CITED IN THE SOURCE DOCUMENT RELATIVE TO THE DRIVERS THAT WILL IMPACT THE REFINERY OF THE FUTURE IN YOUR AREA

- GIVEN THAT IT WILL BE VERY DIFFICULT TO OBTAIN PERFECT CONSENSUS ON THE LONG-TERM OUTLOOK FOR THE REFINERY INDUSTRY, SEEK TO DEFINE AS BEST YOU CAN THE LEVEL OF AGREEMENT WITH THE CONCLUSIONS AND PROJECTIONS MADE THAT IMPACT THE VISION OF THE ROF IN YOUR AREA. ALSO RECORD DIVERGENT AND/OR ALTERNATIVE VIEWS RELATIVE TO THOSE PRESENTED IN THE SOURCE DOCUMENT

- FOLLOWING ARE LISTS OF SOME KEY QUESTIONS, ISSUES, AND ASSUMPTIONS THAT ARE RECOMMENDED FOR DISCUSSION IN EACH BREAKOUT SESSION

QUESTIONS, COMMENTS, AND ISSUES RAISED BY PARTICIPANTS DURING THE PLENARY SESSION

- The "vision" of the industry in which economic growth, environmental invisibility, and job creation occurs simply will not happen because the elements are in conflict with one another.

- Why should the refinery industry strive for environmental invisibility when every other industry gets by with less restrictive regulations?

- There will be less jobs in the industry in the future.

- Environmental "gentleness," not invisibility, should be the objective.

- A strong plea was made that the participants think in terms of radical change for the industry rather than incremental change, the arguments being that radical change will in fact be the saving grace of the industry and incremental change, however attractive and initially cost-effective, will not go far to save the domestic refining industry. A show of hands was asked for to solicit the audience's reaction to the suggestion. The majority of the participants favored incremental change, although a substantial number foresee radical change.

- The industry must remain part of the global industry and thus remain, hopefully, competitive.

- The industry must make every effort to make the best use of raw material.

BREAKOUT SESSION ON

IMPACT OF

GOVERNMENTAL REGULATION

ON THE

REFINERY OF THE FUTURE

Facilitator: **Terrence S. Higgins**
(National Petroleum Refiners Association)

SUMMATION OF THE DISCUSSIONS/DELIBERATIONS OF THE BREAKOUT SESSION BY THE FACILITATOR

The discussion in this session focused on the following issues, which were deemed to be the most critical in regard to impact on the ROF. The conclusions reached are outlined below, along with an indication of the degree of consensus reached: (C) general consensus; (M) mixed views/opinions.

(1. The EPA/Industry Involvement in the regulatory/legislative process. If the industry is to impact the process:

- Early involvement is required (C)
- Must get ahead of the political process (C)

(2. Data Needs

- Must be timely (C)
- Comprehensive (C)
  - Scientifically sound (C)
  - System data (C)
    - Auto/oil (consortium) type
    - Understand engine combustion

(3. MACT Requirements (C, high priority)

- PERF efforts (C)
- Large pump seals (C)
- Flange leaks (C)
- Better measurement methods needed (M)
- Better means to characterize streams (M)

(4. CO_2 Control

- High priority if controls needed (C)
- Product H_2 content may need to increase (M)
- Need to look at energy conservation (M)

(5. Fuel Change (Quality) Concerns

- Additional RFG/CARB gasoline (M)
- Diesel/jet fuel
  - Need to address now (C)
- Coke (M)
  - Potential loss of market
  - Contaminate removal
  - Removal of crude contaminants

(6. Waste Water Toxicity (C)

(7. Waste Water Systems (C)

- Sewer systems
- Zero discharge (C)
- Groundwater protection/remediation (C)
- Pretreatment standards
- Deep well injection

(8. Waste

- Remediation/closing (C)
- Additional listings (C)
- Catalyst disposal (C)
- Product recovery

Summary of Concerns (in order of priority)

(A. Site remediation & closure

(B. Additional waste listings

(C. MACT standards

(D. Waste water toxicity

(E. Zero discharge

(F. Fuel changes

QUESTIONS, COMMENTS, AND ISSUES RAISED BY PARTICIPANTS DURING THE BREAKOUT SESSION

- Can sound science and cost effectiveness be imposed on the regulatory process?

- The industry is getting conflicting messages from EPA relative to the direction it is taking; there appears to be a serious interest in making real improvements in the regulatory process, e.g., getting away from "bean counting" and focusing on the scientific basis for and health effects of regulations.

- Is there an indication (sound data) that oxygenated fuels will achieve the regulatory objectives?

- We (this industry) must develop a partnership with EPA on risk assessment or reconcile differences.

- The industry believes that EPA risk assessment on the Benzene NESHAP is flawed; the industry, however, came in too late in commenting on the regulations.

- It is encouraging that the EPA seems willing to accept site-specific assessments as a basis for compliance; regulatory compliance is a major issue.

- A specific example of the benefit of site-specific assessment and how EPA and the industry need to interact is a case study on how to regulate, conducted in North Carolina, which found that of 10 companies who wanted to use the site-specific analysis, several were already in compliance and the remainder could come within compliance at 10-15% of the expected cost.

- Does this industry want such (interactive) flexibility to achieve compliance? There is comfort in command and control. Many companies do not have the resources to develop alternative approaches.

- DOE and its labs can play an important role in the regulatory process by developing data that can be used to evaluate/assess specific regulations and prove that they are rational. This would prevent scarce capital from being wasted.

- A fundamental question is whether regulations can be based on scientific data. As an example, while oxygenated fuels can reduce CO, the auto/oil consortium data indicate that these oxygenated fuels are not having the impact that was originally envisioned.

- I am skeptical of the suggestion that flexibility in the application of regulations is possible. There is a big gap between local regulators and federal level intent. The problem is that local agencies are paranoid about making exceptions to the uniform application of regulations to all refiners; the issue is how do you incorporate flexibility (into the

regulatory process) on a nonselective basis. It is not a question if it is desirable but how do you do it.

- The industry must develop a database on a time scale where the data can be used to question/challenge regulations. The data must be obtained ahead of the political process.

- We must be cautious about getting into the political arena to gain economic advantage.

- How do you achieve technology transfer from DOE to EPA?

- The industry should not use the terms "bad science" in criticizing the EPA. This makes EPA personnel mad. Clearly differences of opinion exist. More data is needed. The industry should try to work with the EPA to solve problems together and not offend them.

- There is a consensus that a problem exists and the industry and the EPA need to work together.

- There should be a working relationship (a partnership) between DOE, EPA and Congress. The DOE should focus on data acquisition and feed it to the EPA, and Congress to influence policy.

- DOE should provide independent input into the regulatory process and serve as a go-between for EPA and the industry.

- The industry did not get out in front of the political process to head off the Clean Air Act of 1990.

- An important issue in regard to MACT regulations is that of who evaluates new technologies that are developed. Can DOE help in this regard? DOE could oversee tests of such technologies under real conditions, rather than optimum laboratory conditions.

- No consensus evolved from a vote of the participants on what is the best approach for achieving regulatory compliance, command and control vs site-specific risk assessment.

- In our lifetime we will not likely see site-specific risk assessment environmental management. The political support is not there as yet. The issue is how far to push this envelope. You should focus on the economic viability of command and control across the industry; don't criticize one or the other approach.

- Either the government or industry should be able to use the site-specific risk assessment approach.

- A priority for this industry is to address the 1990 Clean Air Act regulations on emissions from stationary sources.

- As long as California keeps pushing nonpetroleum fuels, this industry must treat RFG as a serious issue.

- The work of the auto oil consortium to understand the pollutant/engine relationship must be continued to be able to address the RFG environmental process.

- If the public wants a chemical gasoline we can provide it, but the price will be very high.

- There is a strong need to pursue research addressing MACT Standards and fugitive emissions. We don't have a good grasp of the critical nature of this problem, e.g., the need to develop large sealed pumps.

- The industry should be concerned about the fugitive emission problems, since the EPA will have advanced new technologies to do detailed monitoring.

- We need to be concerned about CO_2 regulations. Pressure is mounting to adopt CAFE type standards on CO_2 emissions.

- CO_2 regulations are of concern "tomorrow" - we need to get up front on this issue, we need to get a head start.

- MACT Standards are perhaps the highest priority facing the industry.

- The industry can expect to see more regulations on other transportation fuels - distillate, diesel fuel, and jet fuels. An important opportunity exists to pursue development of a database on diesel fuels that can impact the regulatory process. We should work with the Europeans who have a study under way. The composition of diesel fuel issue is the same as existed for gasoline a few years ago.

- Coke could be a problem shortly. Now it is exported oversees to Japan, Spain, and Turkey. If these countries stop taking our coke we could face a crisis. We must do something with coke to remove the S, N, and metals. Development of a process to remove impurities from coke would be very worthwhile.

- We can't address all the issues and problems we have identified. We need to come up with a better way to quantify and prioritize the problems and focus on the high priority areas.

- The industry needs to identify what contributions it can and should make to improving the environment.

- We need to develop tools and data that can be used to perform risk assessments.

- The industry must work with auto manufacturers to solve the engine fuel problem.

- A problem that the industry has ignored but which it inevitably must face is odor. It seems certain that public pressure will increase in this area.

- Site remediation is a major problem for the industry.
- Water and solid waste issues will become the most critical concerns, e.g., in regard to water, the toxicity standards may necessitate secondary treatment, metal criteria, imposition of zero discharge, etc.

BREAKOUT SESSION ON

IMPACT OF

MARKET FORCES

ON THE

REFINERY OF THE FUTURE

Facilitator: Bruce Burke
(Chem Systems)

SUMMATION OF THE DISCUSSIONS/DELIBERATIONS OF THE BREAKOUT SESSION BY THE FACILITATOR

The discussions in this session focused on the projections of future trends in key market drivers and their underlying assumptions in order to determine whether consensus exists within the industry relative to its future operating environment. The conclusions and degree of consensus amongst the participants on critical items are as follows. Degree of consensus is indicated by (C) - general consensus or (M) - mixed or split opinions.

Market Projections - General Consensus (C)

- Gasoline demand in 2010 will be about the same as in 1993

  - Strong government mandate
  - Technology breakthrough

  } Required to change demand

- Middle distillate demand to grow 1-1/2% per year

- The ROF should be:
  - Transport Fuels Producer
  - P/C Producer
  - Power Producer

- Crude oil imports will increase significantly, as domestic reserves decline

- Industry fragmentation makes it difficult to recover all additional environmental costs

- Higher quality products will be required, specifically lower fulfur middle distillates and reformulated gasoline

- Higher-value markets need to be developed for "carbon"/coke, residual fuel oil

Market Forces (M)

- Residual fuel oil demand will be flat or decline, largely due to competition from natural gas

- Product imports will be a limited threat to the U.S. industry as alternative global markets will compete for surplus products.

Other Issues On Which The Session Participants Tended To Agree Include The Following

- Profitability will not provide full re-investment economics for new refineries
- Technology/R&D must focus on cost reduction to improve competitive position
- Lower site remediation costs will lower exit barriers to poor performers
- Alternative fuels can impact the ROF and some concern exists about potential inroads. There appear to be no clear winners, with each alternative fuel facing a range of issues:

POTENTIAL ALTERNATIVE FUELS	GENERAL ISSUES
CNG	$-COMPETITIVE POSITION
LNG	MANDATED USE
PROPANE	INFRASTRUCTURE REQUIREMENT
ELECTRICITY	LCA - "TRUE COSTS"
H_2	
SOLAR	
RENEWABLES MASS TRANSIT	

- "Status Quo" ROF vision is generally accepted. There is genuine, though unspecified, concern amongst a small segment of the industry about the possibility of revolutionary change
- Technology/R&D development must consider downside potential for markets
- Benefits of the proposed R&D program likely will become available to overseas competitors

In addition to the above, the session participants agreed to the following general recommendations:

- The Refining Industry needs to be more proactive to address its problems

- Industry needs to work together to identify goals: this raises potential anti-trust legal constraints
- Need for follow-on industry meetings to clarify objectives

QUESTIONS, COMMENTS, AND ISSUES RAISED BY PARTICIPANTS IN THE BREAKOUT SESSION

- Regulations must be compatible with the industry's slow growth prospects
- The ROF should be integrated with petrochemicals
- A higher-value outlet needs to be developed for "carbon"/resid, i.e., coke asphalt
- New refineries are being built overseas in some areas with less stringent environmental standards
- The industry is more fragmented than other mature industries; therefore, the marketplace is not subject to much discipline
- The industry should work to improve the industry's global competitiveness
- How will an electric car or 80 mpg car impact the refinery industry and what is the time frame?
- What should be preserved, Refining or the Transportation business?
- There is general agreement within the industry that (a) gasoline demand will be flat over 20 years (2010), (b) jet/on-highway diesel fuel demand will grow at 1.5%/yr., (c) residual and fuel demand will be flat or decrease, and (d) total product growth will be 0.6% vs 2.5% growth in GOP
- Can RFG meet environmental requirements and compete economically with alternative fuels?
- Do alternative fuels make sense from an environmental viewpoint when their full life cycle impact is considered?
- A lower gasoline demand scenario could evolve through a step change in auto technology; therefore, there is a need for closer collaboration with the auto industry.
- Crude imports will increase; however it is not clear that product imports will do so
- There is no doubt that a change in regulations covering costs of closing refineries would reduce industry capacity. The only question is how much? Every company has one refinery it wants to close.
- Will the transportation infrastructure be able to adapt to closure of inland refineries?
- Imported products depress refined product prices

- Concern exists that the industry will rationalize too much and put itself in a position where it will not be able to respond to demand spikes. Would government regulation as a utility follow? Would a higher return result?
- How should companies work together more with government and each other? Share R&D, etc.
- Employment in refineries on the whole will decrease, since fewer refineries will remain. In turn the surviving refineries will have lower headcounts. More people will be working on regulatory compliance and computer control
- The industry suffers from a bad image. People don't like buying gasoline; it is a necessary evil for using a car.
- Shouldn't the refinery industry get a portion of the $10 billion DOE budget?
- We need to find a "legal" way to work together
- The industry needs to establish objectives and focus so that the technical resources of the country can help address problems and have a high probability to solve them.
- Product import fees should be considered to compensate for higher environmental costs
- An Investment Tax Credit would help boost profitability

BREAKOUT SESSION ON

IMPACT OF

OFFSHORE COMPETITION

ON THE

REFINERY OF THE FUTURE

Facilitator: Gary K. Kohler
(Exxon)

SUMMATION OF THE DISCUSSIONS/DELIBERATIONS OF THE BREAKOUT SESSION BY THE FACILITATOR

The discussion in this session focused on a wide range of issues impacting the competitiveness of the U.S. industry *vis a vis* offshore competition. In addition, a discussion of technology development that could help the industry was pursued. The conclusions reached are outlined below.

Insert A: ROF Vision Regarding Offshore Competition

Report Conclusion:	**No significant impact of offshore competition on domestic refinery industry**
Group Conclusion:	**Impact of offshore competition understated**

Reasons For Offshore Impact

- While refining capacity being built offshore is primarily for local (developing) demand, excess capacity/product mix imbalance could provide U.S. import opportunities

- Differences in environmental regulations onshore vs offshore will directionally discourage U.S. investment
  - Could put smaller refineries at more risk
  - RCRA concerns encourage continued operations in U.S.

Technology Needs (to enhance U.S. Industry competitive position *vis a vis* offshore)

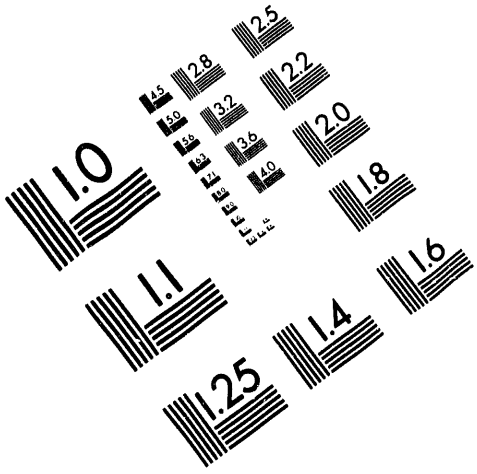
- Design/develop more reliable refinery systems to minimize maintenance costs
- Opportunity to bring more science/risk based analysis to public/environmental regulatory arena
- Development of improved process analyzers to improve operating performance
- Develop market outlets for higher-sulfur petroleum coke

- Lower costs for site remediation. This would make it easier for lower margin refiner to shut down, which in turn would permit rest of industry to enjoy higher capacity utilization/efficiency/competitiveness.

QUESTIONS, COMMENTS AND ISSUES RAISED BY PARTICIPANTS DURING THE BREAKOUT SESSION

- Return on investments in jeopardy for U.S. Refiners if foreign pricing prevents recovery of environmental projects
- U.S. Refinery capacity utilization now in upper eighty percent range. No new grass roots refineries will be built, but incremental debottlenecking is expected. Independent refiners are at risk, as economics of scale will favor larger plants
- New capacity being built primarily in Southeast Asia. How this capacity is handled will affect U.S. situation
- We should avoid trying to take a protectionist philosophy. We should not be imposing tariffs, etc. or other means of protecting the U.S. industry
- Saudis will continue to export. Countries such as Saudi Arabia can obtain 100 percent financing for refining projects from the World Bank. Other countries, such as Indonesia, enjoy the same opportunities. These financing arrangements allow competitive advantages vs the United States
- I question the data in Chem Systems report regarding import projections
- The C.I.S. refining structure is historically structured to serve the military needs. Now there is a need to change to meet the civilian requirements. Developing nations, in general, have different needs than developed countries
- Crude supply and resources will be available to other countries
- Changes in formulations will be tough for smaller refiners. We may well lose some of those properties. There is some question whether all of these quantities will be made up by the larger companies. The difference may be made up by imports
- One impediment to normal resolution of refinery economics and capacity considerations is the high exit barriers. For example, the sale of Exxon's plant to Tosco. If refineries were allowed to shut down, a more economic U.S. refining structure would develop
- If we exported all of the U.S. environmental regulations in their entirety, it would still be economic to build new refineries in Asia

- Import duty and transportation costs will, to some extent, act as a deterrent to importing products
- Looking at the direction of future capital investments, we see 60 percent of U.S. capital investments directed toward satisfying environmental regulations. In Southeast Asia, the corresponding figure is about 10 percent
- Majors are retrenching into more local markets, e.g., Unocal and Arco. I do not see major imports of finished products into the U.S. I do not expect Rotterdam to expand to supply the U.S. But the majors are moving out of the United States. There are more alternate investments available elsewhere. Environmental issues are troublesome here
- Mexico is short of refinery capacity. It is likely to build additional plants and expand
- SASOL expansions II and III were prompted by the threat of embargo. It was a response to the threat of "no crude" due to the South African embargo. The country had some resources, including some refining capacity, and some infrastructure. But it could not depend upon the reliability of imports in event of difficulty
- Crude oil can remain available during an embargo. It is not too difficult to find ways around such limitations. The same is not true for products, however. In event of trouble, imported products will likely not be available
- I do not understand why the United States opposes its own infrastructure. During the embargo, the U.S. pursued shale, coal, tar sands, etc. Projects such as Colony and other alternate energy systems were pursued extensively
- Looking at the "Vision" document, there does not seem to be much threat to the domestic industry within the time frame we are examining
- I do not agree. One indication of possible trends is evident in France. There, oil companies sold 100 percent of all petroleum products as recently as six years ago. France has a refining structure able to supply the entire country. But now, only 60 percent of products is sold by oil companies and 40 percent is sold by "supermarkets," all of which are supplied by imports. There is a significant question as to how to control this type of situation. There is a definite danger, perhaps not for crude oil, but very much so for products



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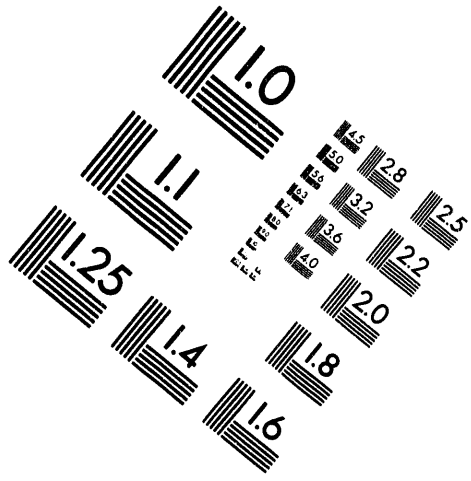

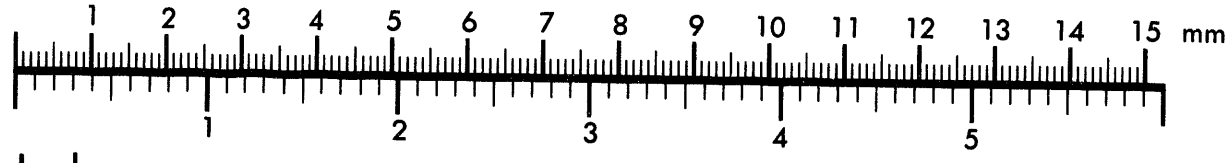

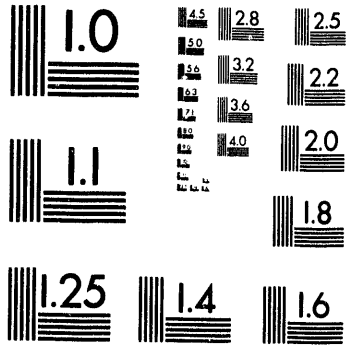

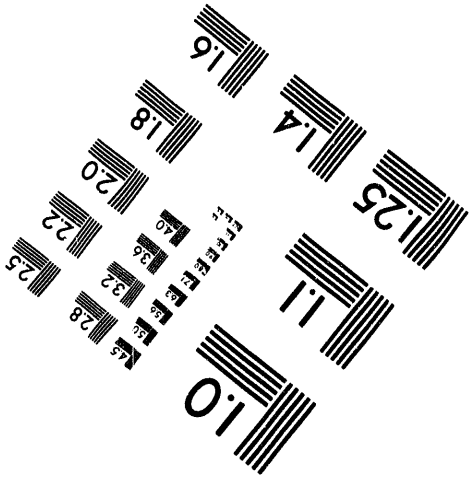

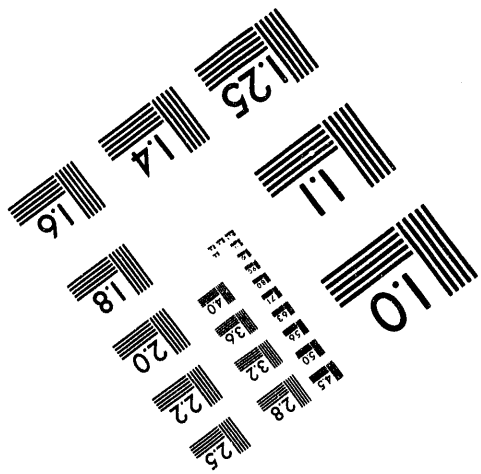

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- Because of long term liabilities, companies will not build overseas to export to U.S. markets. There will be in Asia, in Indonesia, etc. surplus products from time to time which will move to the U.S.
- We don't know what the demand expansion will be, world wide. We can control the dollars invested for non-return investments vs the portion of offshore. Non-return projects could erode the domestic industry.
- I'm more pessimistic. There will be imports in my mind. There will be over-building overseas, and we will see the effects here in the U.S.
- Perhaps we can summarize. (Gary Kohler, Facilitator) There will be a growth of finished and unfinished products faster than the projections shown in the vision of ROF document. The difference between U.S. and foreign situations is that capital can go overseas as a result of environmental regulations, but the effect is negligible as to U.S. competitiveness. Small refineries are particularly at risk. New grass roots refineries offshore can comply with environmental regulations with considerably less expense than retrofitting U.S. refineries. There will be periods of supply/demand imbalance due to leading/lagging demand. These imbalances will self-correct. There is greater uncertainty as to capacity aimed at U.S. markets. Exit form U.S. operations is slowed by hurdle costs.
- Petroleum coke must go to power generation. Refineries must market coke as a long-term product. Power companies like long-term, dependable supply arrangements. It should be possible to market increased coke production in this way. The fuels market is where the home is.
- Total U.S. petroleum coke production is 77,000 tons/day. Total world production is about 90,000 tons/day. Far east cokes have lower sulfur. Desulfurization of coke is not economical, and must compete against stack gas scrubbing.
- We are building concrete and steel. We need for things to get simple. We can build a 2000 psi unit with all the controls. But we need to figure out how to get simple. For example, in the petrochemical industry, we got rid of highly energy intensive, capital intensive products; we don't have high density polyethylene any more.

BREAKOUT SESSION ON

IMPACT OF ALTERNATIVE FEEDSTOCKS

ON THE

REFINERY OF THE FUTURE

Facilitators: Douglas Rundell
(Amoco Oil)

Linda Schilling
(DOE/OIT)

SUMMATION OF THE DISCUSSIONS/DELIBERATIONS OF THE BREAKOUT SESSION BY THE FACILITATORS

The participants in the session were encouraged to take a "broad" view of the key questions posed - namely, can or will the refinery of the future make use of a broad range of feedstock materials; also, can or will it supply a broad range of feedstocks for other industries? A brief summary of the issues raised and discussed is outlined below.

Policy Issues Raised

- Should DOE provide technology/process demos for energy security?
- How do you effectively communicate risks and trade-offs about feedstocks?
- Infrastructure for recycled oil and plastics - San Jose example
- Impact of imported gasoline on prices
- Role of agriculture
- Can always buy crude but not product
- Excess heavy crude refinery capacity exists

Technology Issues (Needs)

Consensus existed on this need for R&D in the following areas:

- Pretreatment of feedstocks
- Crude upgrading at the wellhead
  - sulfur removal
- Water recycling
- More uses for coke

Mixed views evolved on:

- Hydrogen generation and use (management)
- Recovery of organics from low-quality dilute streams
- What is meant by flexibility?
- Who should pay for flexibility?
- Markets for sulfur
- Chemicalization of the industry

QUESTIONS, COMMENTS, AND ISSUES RAISED BY PARTICIPANTS DURING THE BREAKOUT SESSION

- EIA data show that the quality of crude has been decreasing, increasing with sulfur and asphaltene content
- The quality of crude processed in the U.S. may be dictated by the price spread between heavier and lighter crude
- The apparent decline in U.S. crude quality may be a self-fulfilling prophecy because of the large number of refineries that have been built with heavy crude processing capacity. Because such a capability represents a substantial investment, the refiners are searching for and buying heavier crudes to utilize their investment. Thus crude quality is not necessarily decreasing; it reflects a response to earlier capital decisions
- The trend in crude API gravity and sulfur in Europe is not the same as in the U.S. There, the quality of crude is improving. Light crudes are readily available at competitive prices. The North Sea is producing far more oil than previously estimated
- Increased heavy crude use in the U.S. is the result of demand-pull rather than supply-push
- The decline in sweet crude refinery capacity, which has been precipitous over the past decade, is the result of a conscious decision made by refiners who were responding to the threat of a cut-off of the higher grade middle-eastern crude and/or an insufficiency of North Sea crude, and/or increases in Alaskan crude oil supplies
- The concern that refineries may decline because of the possibility of product importation needs to be tempered by the consideration that it is always possible to buy crude but not always possible to buy product on the open market (e.g., gasoline or partially refined feedstocks)
- The Japanese and other countries in the Far East are installing new refining capacities to process heavy crude. The decision to do so is based on the price differential between heavy and light crude
- The use and/or disposal of petroleum coke can be expected to become an escalating problem as heavier crudes are used. It is not clear that the present outlet market (the Mediterranean area) for coke will continue to exist. Development of alternative environmentally sound

uses for coke - e.g., chemical feedstock, power generation, etc. needs to be pursued

- Crude oil will probably not be the only feedstock for the ROF. We need feedstock flexibility. Alternative feedstocks could include recycling other materials, e.g., plastics, agriculturally generated materials, recycled oil, etc.
- There is little support for or interest in long-term alternative feedstocks
- It is not clear how the individual refiner should derive the true cost of using alternative feedstocks. How do you factor in true costs and markets for these alternatives?
- What is the real cost of crude in the U.S. when all costs are considered? The 30/BBL crude of today has an actual cost of $60 - 100/BBL when you take into account the defense expenditures to protect our Middle Eastern allies and their crude. If you account for the full cost, then the economics of recycling and alternatives are self-evident.
- The Federal Government is pushing the use of compressed natural gas (CNG) and liquid natural gas (LNG) as environmentally clean transportation fuels. If this takes off, the demand for crude oil could fall dramatically
- Far Eastern countries are ordering equipment (technologies) for their new refineries that will allow them to process sour heavy crudes and residua because they want equipment that will meet U.S. environmental requirements and they recognize that their own politicians and public pressure will require similar safeguards in the future
- Why not use natural gas as a feedstock, since there could be environmental benefits (methane is excluded from proscribed VOCs)? The reason is that it does not appear to make a whole lot of sense economically
- Assuming practical solutions to technical problems can be found, why isn't biomass being seriously considered as a potential future feedstock? The answer is that there will be enough crude available worldwide for the foreseeable future (even if crude supplies dry up in the U.S.) and because the U.S. is simply not pushing renewables very strongly

- It may be possible to use petroleum coke to make methanol or syngas, even though it is a nonuniform product and its ash has a high metal content; the issue is not whether this technology exists but is it economical?
- Current refining capacity is almost fully utilized (at the 90-92% level). Without increased capacity future needs will not be easily met
- Shouldn't we pursue development of technology to preprocess crude to remove the sulfur?
- A major R&D effort on preconditioning of feedstocks looks like a plausible area for a cooperative effort
- People don't want to be bothered with recycling used oil; collection, transportation, and sorting adversely impacts cost and quality of the recycled oil
- Flexibility to use different feedstocks in the refinery is highly desirable; the cheapest raw materials should be processed to produce the desired products
- What is the cost of and is feedstock flexibility needed in the U.S.?
- What are the long-term implications if coke is banned?
- Japan learned in Desert Storm that if you have money you can always import crude, but not product
- The oil (availability) question is becoming more and more unpredictable
- Transportation fuels are becoming chemicals; as an example, about 15% of future gasoline supplies will be composed of non-fuel-derived compounds (chemicals) such as MTBE. Most MTBE is or will be in the near future made by non-refinery suppliers. This trend if it persists could strongly affect the structure of the transportation fuel supply business
- There is money to be made in a niche market, making products from noncrude feedstocks
- The U.S. will always be a major importer of raw materials; therefore it needs flexibility in use of feedstocks
- There are two groups of refiners, those that upgraded for processing heavy crude and those that did not. A higher price-spread will open up

- The marginal imports drive the price of the products - if environmental costs in the U.S. rise, U.S. imports will increase
- Should DOE build a demonstration plant with flexibility in feedstocks?
- Cheaper and new ways of making hydrogen needs to be developed; also, preprocessing crude to remove the metals will also lower demand for hydrogen
- What is precompetitive and what is preprocessing seems OK
- If the government doesn't regard the industry as strategic, the industry will die

SUMMARY OF REMARKS

BY

PLENARY SESSION CHAIRMAN

ON

VISION OF THE REFINERY OF THE FUTURE (ROF)

In summary, the consensus from the four break-out sessions was that the ROF Vision as presented provides a plausible outlook for future development of the domestic refining industry. Not surprisingly, a number of areas were identified for which there are wide differences of opinion. These included:

- The level of petroleum imports, with some expectations that imports will be higher than those presented.

- Trends in the average quality of crude oil. The Vision presented a continued, though slowing, decline in crude oil gravity and sulfur. The opinion was given that the decline in quality will not be as severe.

- The outlook for demand for residual fuel. The Vision presented a flat demand (no change in absolute terms), whereas a number of attendees expect continued loss of markets for residual fuel.

Finally, an opinion was given that the Vision does not take into account the potential for quantum changes in the use of petroleum, such as complete elimination of gasoline as an automotive fuel. While it was acknowledged that such changes are possible, the consensus of the audience was that the Vision of incremental change was the most plausible.