
APPENDIX A
ONGOING RELEVANT R&D
AT
NATIONAL LABORATORIES

ARGONNE NATIONAL LABORATORY

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• Fouling Mitigation in Processing of Residuum and Heavy Oil	CHEVRON HTRI
• Ceramic Membrane Development	AMOCO CHEMICAL
• Methane Catalyst	AMOCO
• On-Line Process Controls	AMOCO
• Conversion of spent catalyst to marketable products	MILES, INC.
• Improved Resid Upgrading	AMOCO
• Fluidized Bed Upgrading of Heavy Oils and Residual Oils	CALIFORNIA SYNFUELS
• Hydrogen Sulfide Waste Treatment Using Plasma Chemical Technology	UOP
• Microwave Technology Evaluation	WAVEMAT

DOE (GOVERNMENT) FUNDED R&D

- Membrane Assisted Solvent Extraction/Membrane Assisted Distillation Stripping for Removal/Concentrations of VOC's
- Conversion of Catalyst Containing Non-Toxic Metals to Useful Products
- Vitrification of Spent Catalysts Containing Toxic Materials
- Development of Thick Cermet Film Multiple Gas Sensors for Measuring/Distinguishing Trace Concentrations of Different Gases
- Development of a Mini/micro Mass Spectrometer for Trace Gas Detection
- Passive and Active Microwave Spectrometry for Detection of Trace Gases from Remote Locations
- Development of Bi-functional Catalysts
- Development of Models to predict properties of Molecular Sieves
- Oxidation Coupling of Methane to Methanol

ARGONNE NATIONAL LABORATORY (cont'd)

DOE (GOVERNMENT) FUNDED R&D (CONT'D)

- **Membranes for Pervaporation Applications**
- **Heat Integration of Distillation**
- **Structured Packings for Distillation**
- **Development of Complexing Agents for Removal of Heavy Metals from Waste Waters**
- **Solvent Extraction Processes for Removal of Inorganic Components from Aqueous Streams**
- **Two-Phase Flow and Heat Transfer Enhancement in Compact Heat Exchangers**
- **Fouling and Biocorrosion**
- **Development of Computer Codes for Predicting Hydrodynamics and Erosion in Fluidized Bed Systems**
- **Development of Computer Models for Predicting the Hydrodynamics and Pollutant Formation in Reacting Flow Systems**
- **Advanced Mass Spectrographic Methods for Characterization of Resids and Related Fossil Materials**
- **Magnetically Assisted Removal of Soluble Contaminants From Liquid Steams**
- **Recovery of H₂ and Sulfur from H₂S Waste**

BROOKHAVEN NATIONAL LABORATORY

CRADAS

- | <u>CRADA TOPIC</u> | <u>INDUSTRIAL PARTNER(S)</u> |
|---|-------------------------------------|
| • Low Temperature Liquid Phase Catalytic Synthesis of Methanol from Synthesis Gas | AMOCO |
| • Biochemical Production of Adsorbents from Fossil Fuel Wastes | EER LABS |

DOE (GOVERNMENT) FUNDED R&D

- Biochemical Production of Surfactants from Low Grade Oils, Residuum, and Oil Wastes
- Biochemical Upgrading of Heavy Crude Oils and Residuum
- Application of Multitracer Technology to Petroleum Reservoir Studies
- Effects of Selected Thermophilic Microorganisms on Crude Oils at Elevated Temperatures and Pressures
- Liquid Phase Catalytic Synthesis of Higher Oxygenates from Synthesis Gas
- Adsorbent/Natural Gas Vehicle Storage Systems
- Hydrogen Storage on Carbon Adsorbents
- Mechanisms of Metal-Environment Interactions
- Combustion Kinetics and Reaction Pathways
- Fischer-Tropsch Synthesis with Fine Particle Catalysts
- Structure and Reactivity in Catalysis and Advanced Materials
- Hazardous Waste Management Disposal Operations
- Chemical Consequence Analysis
- In-situ Containment and Stabilization of Buried Waste
- Polymer Solidification
- Polyethylene Encapsulation of Single Shell Tank Waste and Ion Exchange Resin Wastes

BROOKHAVEN NATIONAL LABORATORY

(cont'd)

- **Microparticle Analysis by Laser Spectroscopy**
- **Continental and Oceanic Fate of Energy-Related Air Pollutants**
- **Aerosol Chemistry and Dynamics**
- **Atmospheric Tracer and Instrumentation Development**
- **Atmospheric Organic Chemistry: Investigation of Primary and Secondary Species**
- **CO₂ Mitigation Technologies**
- **Citrate Extraction of Heavy Metals**
- **Biodegradation of Selected Organic Compounds and Complexing agents of Radionuclides and Metals**
- **Biochemical and Molecular Approaches to Treatment and Stabilization of Radionuclides and Toxic Metals in Wastes**
- **Produced Water Risk Assessment**

IDAHO NATIONAL ENGINEERING LABORATORY

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• Plasma Upgrading of Heavy Oil and Residuum	PHILLIPS
• Microbially Enhanced Oil Recovery and Biotechnology for Oil Field Operations	PHILLIPS
• Aerobic Biofilter for Hydrocarbon Vapor Treatment	EG&G ROTRON
• Polyphosphazene Membranes for Separations Under Harsh Conditions	UNION CARBIDE
• Automatic Contaminant Sample Analysis (with Los Alamos, et. al.)	ABC LABORATORIES
• Polyphosphazene Membranes for Hydrocarbon Separations	ELF ALTOCHEM
• Polyphosphazene Membranes for Separations Under Harsh Conditions	MEDIA PROCESS TECHNOLOGIES

INDUSTRY SPONSERED RESEARCH

<u>TOPIC</u>	<u>INDUSTRIAL SPONSOR(S)</u>
• Naturally Occurring Radioactive Materials in Oil and Gas Industry Equipment	API, GRI

DOE (GOVERNMENT) FUNDED R&D

- Environmental Modeling, Monitoring, and Assessments of Contaminated Sites
- Supercritical Water Oxidation of Toxic Materials
- Bioremediation and Treatment of Soils, Waste Water Streams, Volatile Organics

IDAHO NATIONAL ENGINEERING LABORATORY (cont'd)

- **Chemical Treatment of Contaminated Waste Water Streams and Sludges**
- **Plasma Conversion of Fossil Fuels to Higher Value Products**
- **Polyphosphaze Membrane Development for Industrial Separation Processes**
- **Hydrogenation Catalysts for Treatment of Emissions, Feedstock Conversion**
- **Three Dimensional, Multiphase Multicomponent Thermal-Hydraulic Experiments and Code Development**
- **Human Factors Performance Related to Industrial Processes, Accidents, Spills**
- **Risk Assessment of complex Industrial Processes**
- **Industrial Plant Life Extension and Integrity Evaluations**
- **Robotic Sensing and Surveillance Systems**
- **Intelligent Process Sensing and control for Industrial Plant Applications**

LAWRENCE BERKELEY LABORATORY

DOE (GOVERNMENT) FUNDED R&D

- **Double Rotation Solid-State NMR for Studying Catalysis**
- **Additive Effects of Scrubber Chemistry**
- **Turbulent Combustion**
- **Combustion Chemistry**
- **Cloud Optical Properties**
- **Aerosol Chemistry**
- **Health Effects of Toxic Substances**
- **Energy Efficient, Low-NO_x and -CO Burners for Residential, Small Industrial, and Commercial Gas Appliances**
- **Improved Techniques for Sediment Toxicity**
- **VOC Contamination - Steam Flood Restoration Modeling**
- **NAPL - Multi-phase, Multi-component Modeling**
- **Lab Studies of Microbiology Transformation of Petroleum Hydrocarbon in Transient Subsurface Environment**

LAWRENCE LIVERMORE NATIONAL LABORATORY

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• New Approaches to Automotive Combustion Systems and Control of NO _x Emission	CUMMINS ENGINE, GENERAL MOTORS
• The Origin and Fate of Toxic Combustion By-Products in Refinery Process Heaters: Research to Enable Efficient Compliance with the Clean Air Act	CHEVRON, MOBIL, ARCO, AMOCO, TEXACO, UNOCAL, GAS RESEARCH INSTITUTE
• Application of High Performance Computing to Automotive Design and Manufacturing	GENERAL MOTORS, FORD CHRYSLER
• Removal of Metals from Heavy Crude Oils using Liquid Exchange Reactions	PHILLIPS
• Biomimetic Catalysts for the Conversion of Methane to Methanol	AMOCO
• Hot Recycled Solid Processing of Oil Shale	AMOCO, CHEVRON-CONOCO
• Reduction of Nitrogen Oxide Emission for Lean Burn Engine Technology	GENERAL MOTORS, FORD, CHRYSLER
• Laminated Metal Composites	ROHR, SUTTEK, PRATT & WHITNEY, ALCOA
• Aluminum-Aerogel Metal Matrix Composites	GENERAL MOTORS
• Superplastic Forming of Stainless Steel Automotive Components	AC ROCHESTER, ARMCO

DOE (GOVERNMENT) FUNDED R&D

- Chemical Kinetic Modeling of Hydrocarbon Oxidation

LAWRENCE LIVERMORE NATIONAL LABORATORY (cont'd)

- **Development of Numerical Models for Prediction of Octane and Cetane Ratings of Fuel Mixtures and Additives**
- **Development of Computer Models for Predicting the Hydrodynamics and Pollutant Formation in Reacting Flow Systems**
- **Modeling Subsurface flow and Chemical Migration of Groundwater Contaminants in Porous Media**
- **Ultrasonic, Digital Radiography and Infrared Imaging for Non-Destructive Evaluation**
- **Combustion Models to Predict Performance and Emissions Characteristics of Reformulated Gasoline**
- **Catalysts from Platinum - Metal Oxide Aerogels**
- **Detection Systems to Measure Ultra-trace Concentrations of Metals in Fuel Oils and Waste Waters**
- **Fully Integrated Pyrolysis Processing Unit to Study Residuum Upgrading, Coprocessing (Plastics, Biomass, Coal, Solid Waste), and Metals Removal**
- **Chemical Reaction Kinetic Modeling for Optimizing Process Performance**
- **Municipal Solid Waste to Hydrogen**
- **Laboratory Test Facility for Aqueous Pyrolysis of Heavy Oil**
- **Laboratory-Scale to Full-Scale Pilot Plant for Solids Circulation Combustion for High Sulfur and Nitrogen Fuels**
- **Dual-band Infrared Imaging to Detect Corrosion, Thinning and Delaminations in Refinery Pipelines and Related Equipment**
- **Modeling of Granular Solids and Slurry Flow**
- **X-ray Tomographic Microscopy of Crack-Resistant Composites**
- **Matrix-Assisted Laser Desorption/Ionization Mass Spectrometry for Complex Mixture Analysis**
- **Thermoelectric Quantum Well Materials for Waste Heat Recovery**
- **Electrochemical, Solid Oxide, and Smart Structure Corrosion and Process Sensors**
- **Porous Carbons and Aerogels: Controlling Structure, Composition and Performance for Gas Adsorption, Energy Storage and Insulation**
- **Vapor Deposition of Multi-layers and Coatings for Corrosion, Abrasion and Thermal Barriers**

LAWRENCE LIVERMORE NATIONAL LABORATORY (cont'd)

- **Site Characterization of Refinery Landsites**
- **High Temperature Catalytic Supports for Combustion and Processing**
- **Remote Optical Measurements of Airborne Chemicals**

LOS ALAMOS NATIONAL LABORATORY

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
<ul style="list-style-type: none">• Oil Recovery Technology Partnership (ORTP)<ul style="list-style-type: none">- Fracture Mapping of Fields Producing from Fractured Limestone and Chalk Formations- Pore-scale Flow and Scaling to Improved Recovery Process- Modeling of Fluidized Bed for Heavy Residual Oil	EXXON UNOCAL
<ul style="list-style-type: none">• Development of Corrosion-Resistant Tubulars (Production Pipe)	EXXON
<ul style="list-style-type: none">• Computational Technology Initiative for the Petroleum Industry - being developed	
<ul style="list-style-type: none">• Plasma Source Ion Implantation	GM
<ul style="list-style-type: none">• Membrane Development	DOW CHEMICAL

DOE (GOVERNMENT) FUNDED R&D

- **Internal Combustion Engine Modeling**
- **Development of Chelating Resins, Polymeric, and Ceramic Membranes for Separations**
- **Nano-Scale Polymer Foams with Controlled Cell Sizes**
- **Laser-Induced Methane to Methanol Conversion**
- **Neural Network and Intelligent Process Control**
- **Atmospheric Modeling**
- **Supercritical Water Destruction of Waste**

NATIONAL INSTITUTE FOR PETROLEUM & ENERGY RESEARCH

INDUSTRY SPONSORED RESEARCH

TOPIC

- Specialized Analysis of Crudes and Fuels
- Refinery Product Problem Analysis
- Fuel Formulation
- Emissions of Alternative Fuels
- Hydro Processing of Specialty Products
- Evaluation of Cat Cracking Catalysts and Feedstocks
- Catalyst and Product Evaluations
- Additive Evaluations
- Properties of Future Diesel Fuels

A partial list of industrial clients who have sponsored such activities include:

PHILLIPS PETROLEUM COMPANY	AMOCO
UNOCAL	ARCO
LYONDELL PETROCHEMICAL	CONOCO
EXXON	MOBIL
UOP	EURON

DOE (GOVERNMENT) FUNDED R&D

- Thermodynamic Properties of Heavy Crudes
- Crude Oil Database
- Analytical Research to Improve Processes

NATIONAL INSTITUTE FOR PETROLEUM & ENERGY RESEARCH (cont'd)

DOE (GOVERNMENT) FUNDED R&D (con'td)

- **Upgrading and Environmental Problems**
- **Coke Reduction**
- **Heavy Oil Upgrading**
- **Analysis of Crudes**
- **Emissions from Alternative Fuels**
- **Fuel and Refining Problems that Lead to Off-Spec Products**
- **Additives Effectiveness and Interaction with Fuels**
- **Waste Minimization and Recycling of Hydrocarbons**

NATIONAL RENEWABLE ENERGY LABORATORY

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• Waste to Fuel Ethanol	AMOCO OIL
• Biomass Wastes into Fuel Ethanol	NEW ENERGY CORPORATION
• Recycling of Nylon - 6 into Monomeric Compounds	ALLIED SIGNAL

INDUSTRY SPONSORED RESEARCH

<u>TOPIC</u>	<u>INDUSTRIAL SPONSOR(S)</u>
• Fluid Catalytic Cracker Catalyst Development	AMOCO OIL

DOE (GOVERNMENT) FUNDED R&D

- Plastics recycling
- Photocatalytic oxidation of organics (VOCs, TCE, etc.)
- Development of cellulose ester membranes (organic/inorganic hybrid and mixed esters) for gas separation
- Increasing fuel flexibility in the refinery industry (oxygenates from biomass)
- High reactivity solids processing
- Syngas production and processing for fuels from biomass
- Production of hydrogen from reforming pyrolysis oils derived from biomass
- Hydrogen production via solar-thermal, photoelectrochemical, and photobiological processes

OAK RIDGE NATIONAL LABORATORY

CRADAS (IN NEGOTIATION)

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• The Biological Removal of Sulfur Heteroatoms from Petroleum	THRU PERF - TEXACO - OTHERS
• PCB Removal & Destruction	MORRISON & KNUDSEN
• Fluid Flow	DOW CORNING
• Particle Size Control	DOW CORNING
• Bioreactor Evaluation for TCE Destruction	ENVIROGEN
• Bioremediation	SCSC
• Advanced Bioreactor System	DOW CHEMICAL
• Scaling and Corrosion in Supercritical Water Oxidation	MODEC
• Electric Fields to Enhance Industrial Processing	ROHM HASS

INDUSTRY SPONSORED RESEARCH

<u>TOPIC</u>	<u>INDUSTRIAL SPONSOR(S)</u>
• Scaling and Corrosion in Supercritical Water Oxidation	MODEC
• Electric Field to Enhance Industrial Processing	ROHM HAAS

DOE (GOVERNMENT) FUNDED R&D

- Flow and Bubble Formation in Vapor-Liquid Process
- Bioconversion and Recycle of Lignocellulosic Materials
- Alternative Feedstocks for the Chemicals and Petroleum Industries
- Biofuels Feedstock Development
- NO_x Reduction Additives

OAK RIDGE NATIONAL LABORATORY (cont'd)

- **Neural Networks for the Identification of Fuels**
- **Advanced Waste Minimization Methodology - Waste Minimization Evaluation Model**
- **Software for Prediction of Thermodynamic Properties**
- **Interactions of Solvents, Solutes, and Surfaces: Adsorption and Supercritical Extraction**
- **Multicomponent Separations by Continuous Chromatography**
- **Renewable Hydrogen Production for Fossil Fuel Processing**
- **Sludge Mixing/Mobilization**

PACIFIC NORTHWEST LABORATORIES

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
• Hydrothermal Destruction of Organics	ONSITE * OFSITE
• Petroleum Catalyst Recovery	PHILLIPS
• Waste Acid Recovery Demonstration	VIATEC
• Solid Superacid Catalysts	UNOCAL

INDUSTRY SPONSORED RESEARCH

<u>TOPIC</u>	<u>INDUSTRIAL SPONSER(S)</u>
• Ion Exchange for Heavy Metals	UOP
• Petroleum Sludge Treatment	ONSITE * OFSITE
• Hydrodeoxygenation of Biocrudes	VEBA PETROLEUM

DOE (GOVERNMENT) FUNDED R&D

- Hydrothermal Deduction of Organics
- Electrochemical Destruction of Organics
- Corona Destruction of VOC's in Off-Gas and Water
- Efficient Separations and Processes Integration Program
- Polymer Membrane Separations
- Extraction of TCE
- In-situ bioremediation
- Composting of Fuel Contaminated Soil
- Catalysis-by-Design
- Development of Membrane Reactor System
- Development of Ceramic Membrane Materials
- Alkane Oxidation

SANDIA NATIONAL LABORATORIES

CRADAS

<u>CRADA TOPIC</u>	<u>INDUSTRIAL PARTNER(S)</u>
<ul style="list-style-type: none">• Study of Catalysts (physical structure, gas adsorption, electronic structure) using <i>ab initio</i> codes on massively parallel computers	BIOSYM TECHNOLOGIES, INC. EXXON
<ul style="list-style-type: none">• Catalysts for Production of Oxidized Products	SHELL DEVELOPMENT, HOUSTON
<ul style="list-style-type: none">• NO_x Reduction Catalysts	LOW EMISSIONS PARTNERSHIP (LEP)
<ul style="list-style-type: none">• Inorganic Membrane Reactor Technology to Provide Improved Energy Utilization in High-Temperature Petrochemical Applications	AMOCO
<ul style="list-style-type: none">• Hydrous Metal Oxide Catalysts for the Synthesis of Oxidized Products	SHELL
<ul style="list-style-type: none">• The Origin and Fate of Toxic Combustion By-Products in Petrochemical Process Heaters: Research to Enable Efficient Compliance with the Clean Air Act	TEXACO, CHEVRON, MOBIL AMOCO, UNOCAL

DOE (GOVERNMENT) FUNDED R&D

- Conversion of Light Hydrocarbons to Alcohols Using Biomimetic Catalysts, Carbon-Based Catalysts
- Conversion of Carbon Dioxide Using Biomimetic Catalysts
- Molecular modeling of Macromolecular Structure of Complex Hydrocarbons and Fuels
- Nanostructured Metals, Oxide and Sulfides for Catalytic Applications
- Selective Dehydrogenation Catalysts and Membrane Reactors
- Development of Thin Film Hydrous Metal Oxide Catalysts for Fuels Applications

SANDIA NATIONAL LABORATORIES (cont'd)

- **Design and Development of Smart Membranes for Small Molecule Separations (several projects)**
- **Design and Development of Porous Materials for Small Molecule Adsorption and Storage**
- **Catalyst Development for Direct Liquefaction**
- **Catalyst Assessment and Reactor Fluid Dynamics**
- **Catalytic Hydrolysis**
- **Refining of Coal-Derived Liquids**
- **Thermally Stable Jet Fuels**
- **Advanced Liquefaction Concepts**
- **Solar Detoxification of Organic Contaminants**
- **Technology Demonstration**
- **Opportunities in the Petroleum Industry - Vital Issues Panel for EPA Act section 2108 Report to Congress**

APPENDIX B
MATRIX OF NATIONAL LABORATORY
CAPABILITIES IN
RELEVANT R&D AREAS

Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.1 Environmental Research and Development											
Waste Water Treatment											
Metals Removal	XX	XX	XX	S	S	XX			XX	XX	S
Enclosed Biotreatment systems	C	S	XX	S	S	S		S	S	XX	C
Reverse osmosis-membrane filters			S								
Precipitation of metal contaminants	S	S	S	C					XX	XX	
Adsorption on media (activated carbon)		C			S				XX		S
Sand filtration							C				C
Solar Detox								S			S
Waste Water Sludges											
API Separator Sludge	C	C	S	C	S				C	S	
Tank Bottom Sludge		S	S		S		S		S		
Solid Waste Disposal											
Air Flotation Float Solids										S	
Spent Catalyst Handling	XX	C									C
Gaseous Emissions											
Flue Gas Emissions	XX	XX	S		S	XX			C		S
Combustion Processes	S	XX			XX	XX	XX	S			XX
Regulation of emissions	XX	XX	S		C				S		S
Site Remediation											
In-Situ treatment	S	XX	XX	S	XX	XX			XX	XX	XX
Total System Analysis	XX	XX	XX	S	XX	XX			XX		XX

XX = Strength Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]
S = Significant Capability Defined as 10 - 29 manyears of effort in this category over the last 5 years
C = Capability Defined as 5 - 9.9 manyears of effort in this category over the last 5 years

Note: Activities of less than 5 manyears effort over the last 5 years should not be claimed on the form.

Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.2 Advanced Base Technology Development for Process Improvement											
Energy Efficiency Improvements Thermal Processes											
Organic/fluid fouling	XX		C				S				
Two-phase heat transfer enhancement	XX	S	C			XX		XX	XX		
Transport process in compact heat exchangers	XX	XX	C			XX		XX	S		
Studies of process unit integration	S	XX	C			XX		C			
Development of a Comprehensive Computer Simulation of a complex refinery of the future	C	S	XX	XX					XX		C
Catalysis											
Catalyst by Design	XX	XX	C	S	XX	XX	C		S	XX	XX
Solid Acid Catalyst Replacements for HF and H ₂ SO ₄										XX	C
Catalytic Oxidation of Hydrocarbons	C	S	XX		C	C	C			XX	S
Environmental Control Catalysts						S					S
SO ₂ --> SO ₃					S						
Synthesis of Molecular Sieves	S	XX		S	C						S
Post Combustion Catalytic emissions Control	C		S			XX					C
Separation Science											
Distillation					C		C				
Membranes	C		XX	S					XX	XX	XX
Adsorption		C				C	C	XX	XX	XX	C
Extraction	XX						C			XX	
Combustion Science		XX			XX	XX		C	C		XX

XX = Strength

S = Significant Capability

C = Capability

Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]

Defined as 10 - 29 manyears of effort in this category over the last 5 years

Defined as 5 - 9.9 manyears of effort in this category over the last 5 years

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Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.2 Advanced Base Technology Development for Process Improvement (cont'd)											
Knowledge Based Control Systems											
Sensors	XX	C	XX			XX			XX		XX
Refinery Model Simulation	S	XX	XX	S					S	C	C
Chemical Reactor Phenomological Modeling											
Fluid Bed modeling, Erosion/corrosion	XX	XX	XX	C		XX			XX		C
Chemical Reaction modeling	S	XX	S		C	XX		C			XX
Materials Degradation / Long-Term Reliability / NDE											
NDE	XX	XX	XX			XX			XX		XX

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Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.3 Process Development											
<i>Increasingly important</i>											
Hydrocracking					C	C				C	
Resid Hydroprocessing	C	S			C		XX			C	C
Distillate hydrotreating/processing					C		XX				C
Oxygenate Production	C	XX	C		C		C	C	C		C
Resid partial Oxidation	C				C					C	
Flexicoking					C						
Distillation					C		S				
Hydrogen Production	S		C	S	C	XX	C	XX	C		C
<i>Same Importance</i>											
Catalytic Cracking					C						
Isomerization					C					C	
Alkylation					C					C	
<i>Decreasing Role</i>											
Delayed Coking					C						
Catalytic reforming	S	C			C						
Solvent deasphalting					C						
High-Risk process development											
Petroleum Coke Desulfurization		XX			C						
Petroleum Demetalization	S	XX	C		C		C		C		C
Hydrogen Production Technology	S		C	S	C	S		XX	S		C

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C = Capability Defined as 5 - 9.9 manyears of effort in this category over the last 5 years

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Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.4 Yield Improvement from Heavy Oils and Resids	S		S								S
5.3.5 Alternative Feedstocks											
Co-Processing	S	C							C		C
Plastics Recycling	S					S	C	S			C
Biomass Co-processing						S		XX	S	S	C
Coal Co-processing	S					S			XX		C
Natural Gas Utilization	C	XX	S			C	S		C	S	S

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**PLENARY SESSION ON
OTHER MATTERS**

**Session Chairman: Skip Robinson
(BP America)**

The Plenary Session on other issues was designed to provide the participants with a forum for discussion of items not on the agenda, e.g., program characteristics, implementation options, etc. The items discussed are summarized below.

Other Issues

- **Drivers Impacting Program Startup**

Justification of a cooperative DOE/industrial program will require both industrial "push" and government "pull". The refining industry must express both want and need for a collaborative program, whilst the DOE must show that government support of the refining industry is in the best interests of the nation. In session discussions reviewing the impact of various drivers on the U.S. refining industry there was some disagreement on the role of foreign competition (product imports) on domestic refining. Foreign competition is of course a subject of concern to the U.S. government, particularly if it is onerous to an industry which is considered strategic to national security.

- **Technical (Program)**

- **What are the best areas for DOE/Industry collaboration?**

Technology plays an important role in refining, and for some companies provides a key competitive advantage. Government involvement in certain areas such as process development or operational enhancement could be viewed by some as an unwelcome intrusion. However environmentally focused programs had greater appeal due to the perceived universal cost of compliance and lack of opportunity for attaining competitive advantage. Thus determining the scope and breadth of the collaborative program is a key issue that needs to be resolved

- **Intellectual property rights**

Concern was expressed over ownership of new technology or technological enhancements discovered with government supported programs. The DOE has policies under existing programs that address intellectual property rights, patent ownership, etc.

- **Program Management**

Concern was expressed over how co-funded programs would be managed and controlled and how costs would be shared with the DOE

- **Timeliness**

The U.S. government fiscal cycle begins in October. Thus the '95 year will begin in October 94. It is unlikely that a

major DOE/Refining program could be included in the '95 budget due to the long approval process faced by any government department. However the timing is good to gain approval for fiscal '96, which would start in Oct. '95.

- **Industry Representation to DOE**

A key issue in establishing a joint DOE/industry collaborative program is who or how should industry represent themselves to the DOE. What kind of mix of refiners, suppliers, vendors, etc. would be considered an adequate representation of the industry? What percentage of participation is required, if any? Are any of the existing organizations adequate, such as API, NPRA, NPC, etc. or is a new organization, such as PERF required? If so, who should take the initiative to organize and manage the new body?

QUESTIONS & COMMENTS OF THE PARTICIPANTS

- The issue of whether the NPRA would be interested in representing the industry in discussions with DOE has been raised with the organization. Direction is being sought.
- Does there have to be unanimous agreement of all the members of NPRA?
- PERF will also discuss the options and may set up an appropriate group.
- The industry should consider an organization analogous to of the Natural Gas Council in order to deal with DOE. This is an important issue that needs to be addressed.
- Should company representatives (on an industry organization) be from research and development or operations?
- We should have more of these meetings (workshops) to encourage communication.
- What was the reaction of the upper-management-level officials of the oil companies you talked to relative to the question of industry representation? We got mixed recommendations: approximately one third suggested NPRA, another third recommended a new organization be created, and the remainder suggested PERF and other organizations, such as API and CRC.
- The industry must talk to DOE management at sufficiently high levels and stress the importance of the industry to the economy.
- What we are dealing with here is more complicated than just the technical aspects of a collaborative program. The DOE is asking for more - that we work in partnership with the Labs and put up money.
- DOE is acting as a government facilitator seeking to determine if we want to form a partnership.
- The refinery industry should have more involvement in the U.S. Clean Car Initiative to develop an 80 mpg car.
- The industry needs to pay more attention to the car industry and the impact of its advances on fuel composition.
- Can the DOE work with foreign-owned companies? Yes, if they do work in the U.S.

- **What's next? We have to await feedback from the NPRA and PERF meetings.**

WRAP-UP/CLOSING REMARKS

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

WRAP-UP/CLOSING REMARKS

WORKSHOP EXPECTATIONS, WERE THEY MET?

- The direct relationship of the Refinery of the Future program to the Mission of the Department of Energy was emphasized. Secretary of Energy Hazel O'Leary presented the strategic importance of the energy industry February 9, 1994 at the Cambridge Energy Research Associates annual energy conference in Houston.
- Additional, meaningful, input was obtained for the Refinery of the future industry "vision". In some cases the draft "vision" document was challenged, but for the most part the information obtained through the initial industry interview process was still pertinent.
- DOE has stimulated the refining industry to openly discuss its future technology needs, in particular as they relate to resolving regulatory requirements.
- The core competencies of ten DOE national laboratories were presented as a DOE capability available to support the technology needs of the refining industry.

WHAT DID WE HEAR?

- Excellent feedback was received from the breakout sessions, and summarized in plenary sessions.
- DOE Deputy Secretary Bill White has offered to address intellectual property and other legal issues that inhibit the establishment of a collaborative program with the refining industry.
- The ROF started as a process to provide strategic focus for the technology development programs in EE and FE. Although the need still exists for DOE to develop comprehensive, strategic, programs to support its technology development activities, this of itself is not sufficient evidence to justify DOE's involvement in such a program. What is needed is a strong message from the industry that outlines its future directions (vision), its critical problems and hence its needs; this message needs to be communicated to the appropriate levels of DOE management.
- The ROF "Vision" as presented at the Workshop is sufficient to establish the basis for a collaborative program to address the future needs of the refining industry.

- The Refining industry now has the opportunity to make the ROF a truly national program. Several major industrial partnerships with DOE include automotive (U.S. Car), and textiles (AMTEX).
- There are currently major policy opportunities for the refining industry to be publicly heard.
- The refining industry must find a way to overcome the industry's varied and conflicting interest to promote a vision of its future, and its problems, to the nation. This has to be the industry's initiative and vision, not DOE's.
- DOE will continue in a facilitating role. We want your ideas on how to do this. DOE will help facilitate the surfacing of all the right messages.
- There are many models to select from in developing an interaction with DOE. Industry must drive the process and develop viable technology options for survival.

WORKSHOP FOLLOW-UP ACTIONS

- The workshop proceedings will be issued to the participants. A number of individuals have expressed the opinion that no further work be done to improve or refine the industry "vision" that has been presented in the Refinery of the Future draft document. This document will continue to evolve with time, but is sufficient to establish a basis for a collaborative program to address the future technology needs of the refining industry.
- The unified presentation on national laboratory core competencies was positively received, with interest expressed in seeing the concept of a "single point of entry to DOE" further developed. DOE agreed to continue to work toward this objective.
- It was recognized that other DOE offices should be involved in the ROF program, notably Environmental Restoration and Waste Management. Both Energy Efficiency and Renewable Energy, and fossil Energy, have been working closely since the start of ROF program plan development. More recently, Energy Research and Defense Programs have been briefed on the program.
- DOE will continue to facilitate discussions, meetings, or other interactive modes to assist the refining industry in developing an industry "vision" of the future. This "vision" will have the most impact if it is truly representative of the refining industry's needs.
- DOE will take a lead role in championing the refining industry with EPA, as directed in the Domestic Natural Gas And Oil Initiative.

NPRA WORKSHOP EVALUATION

The NPRA conducted a survey of the Workshop attendees at the conclusion of the Workshop to obtain their views on the value of the Workshop and potential interest in collaborative research. The results of this survey are given in Attachment I. Specific comments submitted by attendees are summarized in Attachment II.

Attachment 1

Workshop Evaluation

	<u>Refiners</u>	<u>Technology Firms</u>	<u>Consultants</u>	<u>Other</u>	<u>Total</u>
Value of the Workshop¹					
Usefulness of Information	2.9	2.8	3.0	3.3	3.0
Understanding of Purpose	2.7	2.9	3.0	3.5	2.9
Overall Value	2.9	2.8	3.1	3.2	2.9
Potential Interest in Collaboration Research²					
Strong	54	75	50	22	33
Moderate	38	25	50	22	33
None	8	-	-	-	3
Interest in Broad Range	23	25	33	44	28
Interest in Limited Scope	77	75	67	56	72
Continue to Pursue Activity	59	75	100	88	73
Review with Others	13	25	-	12	19
Both of the Above	18	-	-	-	8
DOE Should Continue Dialogue	88	94	100	100	93
Wait for Industry Response	12	6	-	-	7
Discontinue Effort	-	-	-	-	-

1 Rated on scale of 1 to 4, with 4 being the highest

2 Percent of respondents indicating response

Attachment 2

ROF Workshop Comments

REFINING AND PETROCHEMICAL MEMBER COMMENTS:

1. VALUE OF WORKSHOP

- Feel the program was effective to get the door open for National Labs and industry to work together.
- Value will depend upon what happens next. Need to develop process for collaboration between industry and National Labs/DOE/EPA.
- I was a little confused as to the objective of the workshop, thinking that the discussion would center around a vision of the refinery in 10-20 years. We discussed more short-term needs rather than long-term vision.
- Great start - wonderful example of TQM - value will be seen based on respective organizations. This program needs one interface organization, i.e., NPRA.
- Presentation on DOE/National Lab capabilities was very well done. This was a big step forward in making those capabilities more acceptable to the industry.
- Information from DOE was interesting and informative. We will pursue details further. I think results of certain work of National Labs would be appropriate for symposium such as the NPRA annual meeting.
- The workshop was very good. the only negative comment I have is that the breakout groups were so long that reaching consensus was cumbersome.
- Workshop provided good status report on progress and status to date on the ROF initiative.
- Much of the information is "obvious" as it's discussed - the key value was where everybody's interests seem to coincide.
- Refinery of Future is in essence being designed by political science, not real science and driven by confusing government mandates - not gas electric cars, emissions, ethanol, punitive taxes, subsidies. This will cloud industry's ability to clearly establish leveraged R&D goals. First priority is to synergize EPA and DOE.
- Success depends on what the DOE and the labs do.

- Facilitators in some sessions allowed a free flow of ideas; in others they may have limited some of the brainstorming. I am sure we will get better at it as we go along!
- Needed more representation from companies in applied technology.
- Workshop purpose was unclear in pre-meeting literature. Facilitation of workshop sessions could have been better.
- More time should be spent on determining mechanism of working together, less time spent redefining vision of ROF and technology needs.
- good exchange of information - but much focus on "general" issues and less on specifics.

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- Strongest consensus among refining industry; re: need for government partnerships in R& D is in environmental area. I'd like to work toward making this happen. It also happens to be the industry's strongest driver. PERF could be industry spokes group for this initiative.
- The partnership between the refining industry and DOE is vital to the future viability of the domestic oil and gas industry. DOE needs to communicate the strategic value of our industry. We need to continue developing the national energy strategy.
- Broad range - at this time too early to properly limit scope - not enough knowledge to effectively limit. currently, EPA and states are significant interface with refiners on local level - need to address this interface and its relationship to the results of this effort - the R&D programs presented will be most effective if results can be integrated into the development of current and future regulations. In this manner, Industry, DOE, EPA, can reach a consensus agreement on results of R&D and then develop programs to implement regulating requirements. The development of a follow-up procedure, appears crucial for continued success. This procedure should include a mechanism for on-going interaction. There should also be a clearer definition of the relationship between DOE, EPA, Industry to define the ground rules and mechanism for interpretation.
- Limit scope to environmental
- In my opinion, we need an ongoing dialogue to establish the process for moving forward. Industry clearly needs to express interest. It would be very helpful for DOE to sponsor/facilitate an ongoing discussion.
- There are some concerns that arose which have not been satisfied for me: (1) Justifying the DOE and Technology budget increases of 25-30% when, as taxpayers, we have been lead to believe government is to shrink. (2) If refining sector does not work with DOE, and the National

Lab/Technology workshop - then why was agenda geared to technology issues?

- **Definite potential here. An industry focal group is needed to alert industry of the work being done and the potential of the program. The NPRA should probably sponsor this group.**
- **Research partnership activities in certain specific areas would be welcomed by oil industry; needs to be focused, targeted, with milestones etc. to introduce sense of urgency and measures of progress for industry. Broad-based program initially will get no support. Need to establish curve on discussions and get on with it.**
- **DOE should continue dialogue with industry in the environmental area. PERF comes to mind as the appropriate vehicle for interaction. Beyond PERF, I think it will be difficult for the industry to coalesce to a group that can guide a large program. Maybe for now a series of well-publicized CRADA's will need to form the basis for a broader program later on. I think the DOE needs to take a very aggressive role in communicating with the industry.**
- **Devise mechanism to leverage industry R&D through DOE, universities, and private facilities. Require further clarification about DOE, allocation of R&D funds between industries and the availability of non-years R&D adjustment within DOE.**
- **Maybe joint NPRA of API funding could be possible. Work with these organizations.**
- **This is a good start in trying to pool our resources and making best use of our join thinking. We need to have a few successful programs going and will publicize so those that are tentative will come out and support this effort.**
- **Need to focus on what is the national energy policy. From this basis, develop strategies to identify research and development efforts for the industry.**
- **To an operating company, participation in early research is very limited. We would be interested in helping set priorities and utilizing commercial results.**
- **We need to begin implementation steps. Let's get going with some early successes. Don't see great value in "refining" the research plan.**
- **We need to have some way to bring the industry together on studies of common interest.**
- **Need to crystallize the process and develop the mechanism for carrying the interest forward.**
- **DOE should continue; but industry needs to respond to this initiative.**

- Would like to see some mechanisms put in place to carry out some of the issues/programs discussed in this workshop.

CATALYST AND TECHNOLOGY COMPANIES:

1. VALUE OF WORKSHOP

- Too diverse a group; need more focus.
- A lot of the discussion appeared to be a restatement of the previously published papers.
- Information was not available far enough in advance. To be fair, there was apparently a breakdown between my secretary and MPRA - she thought I was registered . . . NPRA had no record of it.
- Advance materials - excellent.
- Meeting structure - very good; R&D plan session a little long.
- R&D meeting required tighter focus (e.g., we drifted into whether DOE should study global warming - in the process R&D session) and better sense of how the feedback would be/could be acted on.
- Unwillingness of facilitator and participants to entertain nontraditional ideas or thought processes (one session rejected FCC Technology Alternatives as heretical or too "radical"). Most seemed more comfortable with gently extending the edges of current or traditional practices.
- I realize the workshop was to "exchange" views, but now that views have been exchanged, I don't see how the ideas get implemented.
- The workshop focused attention on issues and problems that need to be addressed to meet the future needs of the refining industry. It also provided opportunity for mutual understanding.
- Would like to see more refining companies involved in this type of workshop.
- I don't believe all the participants understood the purpose of this workshop. Many of the participants derailed the process of problem definition because they did not understand the long term nature of this effort. By the way, I was clear on the purpose based on an earlier meeting with DOE personnel.

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- As a technology provider, we are interested both in applying National Labs technology in commercial applications, and in leveraging R&D initiatives of our own via the DOE and National Labs.

- Would like to discuss problems involving on-site medium to larger scale demonstration plants.
- You all are up against an industry mindset that is anti-government, anti-regulation and reactive in approach. Tough group but worth trying to move forward. Good luck.
- National Lab's capabilities are quite impressive. There is nothing wrong with salesmanship and self-promotion to increase utilization by private industry.
- DOE should come forward and provide a meeting session for government and industry to solve national problems together. DOE can bring forth their experience in other industries to help the refining industry.
- Need better definition of how to address competitive concerns, protect confidential inf., how to communicate projects, need more long-term thinking on how to get to the market. NPRA should facilitate this with DOE. Organizations like PERF will leave out "Nonrefiners". Need input from all interested parties. PERF too narrow in focus.
- This is just the beginning. There is a lack of communication between the industry and the government. There is a lack of a common frame of reference. Industry's definition of long-term is different from DOE's. We also don't seem to agree on what is basic vs. applied research. Efforts should continue to better communicate and develop a plan based on real needs.

CONSULTANTS:

1. VALUE OF WORKSHOP

- Two basic points: (1) Don't let the momentum stop to formulate similar programs as USCAR, textile, etc. and (2) Don't forget other Labs outside of the National Laboratory system (plenty of talent elsewhere).
- Excellent first effort. Need to develop action plan to implement the program.
- This was good, but it shows a very broad range of industry opinions on where we are and where we are going. shows the strong fragmentation in the industry.
- A start for an organized effort of industry/government association and communication.
- Session objectives were not totally clear resulting in early misunderstandings and start-up problems.

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- **I want to know more about DOE programs (especially technology transfer) and how to get my firm in this industry.**
- **Ensure that lines of communication are kept wide open. Consider electronic access to DOE/National Lab activities (similar to new EPA bulletin board).**
- **The ability to transfer knowledge learned from other forums to refinery application is high value potential. Industry wide data could be provided by DOE. Also analytical techniques is an area of interest.**
- **One issue more important than that of the National Labs is the coordination and exchange of information between companies. A good program to view would be joint meetings on mechanical integrity and deep water development in oil and gas sector.**
- **Limited research approach is best due to highly competitive refining industry with much proprietary ownership of technologies/data.**