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Joint United Nations Development Programme / World Bank

ESMAP

Energy Sector Management Assistance Programme

Harmonization of Fuels Specifications in Latin America and the Caribbean

Report No. 203/98EN

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JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run as part of the World Bank's Energy, Mining and Telecommunications Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and bilateral official donors in 1983, it focuses on the role of energy in the development process with the objective of contributing to poverty alleviation, improving living conditions and preserving the environment in developing countries and transition economies. ESMAP centers its interventions on three priority areas: sector reform and restructuring; access to modern energy for the poorest; and promotion of sustainable energy practices.

GOVERNANCE AND OPERATIONS

ESMAP is governed by a Consultative Group (ESMAP CG) composed of representatives of the UNDP and World Bank, other donors, and development experts from regions benefiting from ESMAP's assistance. The ESMAP CG is chaired by a World Bank Vice President, and advised by a Technical Advisory Group (TAG) of four independent energy experts that reviews the Programme's strategic agenda, its work plan, and its achievements. ESMAP relies on a cadre of engineers, energy planners, and economists from the World Bank to conduct its activities under the guidance of the Manager of ESMAP, responsible for administering the Programme.

FUNDING

ESMAP is a cooperative effort supported over the years by the World Bank, the UNDP and other United Nations agencies, the European Union, the Organization of American States (OAS), the Latin American Energy Organization (OLADE), and public and private donors from countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States of America.

FURTHER INFORMATION

An up-to-date listing of completed ESMAP projects is appended to this report. For further information, a copy of the ESMAP Annual Report, or copies of project reports, contact:

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(ESMAP)

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Contents

Tables

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Abbreviations and Acronyms

ARPEL	Asistencia Recíproca Petrolera Empresarial Latinoamericana
ASTM	American Society for Testing and Materials
b/d	barrels per day
CARB	California Air Resources Board
CARICOM	Caribbean Community and Common Market
CIDA	Canadian International Development Agency
CO	carbon monoxide
ESMAP	Joint UNDP/World Bank Energy Sector Management Assistance Programme
EU	European Union
FCC	fluidized catalytic cracking
g/l	grams per liter
GPA	Gas Processors Association
kg/m^3	kilograms per cubic meter
km	kilometer
kPa	thousand pascals
km^2	square kilometers
l	liter
LPG	liquefied petroleum gas
MERCOSUR	Mercado Común de Sud América
MON	motor octane number
MTBE	methyl tertiary butyl ether
NAFTA	North American Free Trade Agreement
NO	nitrogen monoxide or nitric oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
PM_{10}	particulate matter with an aerodynamic diameter smaller than 10 μm
ppm	parts per million
psi	pounds per square inch
RON	research octane number

RVP	Reid vapor pressure
SO_2	sulfur dioxide
SO_x	oxides of sulfur
T50	temperature at which 50 volume percent of fuel evaporates
TEL	tetraethyl lead
UNDP	United Nations Development Programme
U.S. EPA	United States Environmental Protection Agency
vol%	volume percent
wt%	weight percent
wt ppm	parts per million by weight

Glossary of Terms

Aromatics Hydrocarbons that contain one or more benzene rings in their molecular structure. Aromatics have valuable anti-knock (high octane) characteristics.

Benzene An aromatic hydrocarbon with a single six-carbon ring and no alkyl branches.

Butane A gas, often sold as liquefied petroleum gas (LPG), which has a high octane number and that can be used as a high-vapor-pressure motor fuel supplement.

Catalytic converter A device built into the exhaust system of an engine containing a catalyst that converts carbon monoxide (CO) to carbon dioxide; unburned hydrocarbons to carbon dioxide and water; and nitrogen oxide (NO) to nitrogen and oxygen.

Cetane index An estimate of cetane number based on an empirical relationship with density and volatility parameters.

Cetane number An empirical measure of a diesel fuel's ignition quality that indicates the readiness of the fuel to ignite spontaneously under the temperature and pressure conditions in the engine's combustion chamber. The cetane number is determined using the methodology presented in ASTM Standard D613.

Hydrocarbons Organic compounds composed of carbon and hydrogen.

Light fuel oil A distillate fuel oil containing hydrocarbon components that are similar to diesel fuel components and contains no residual fuel components.

Motor octane number The octane value of a fuel, determined using the engine conditions defined in ASTM Standard D2700-97, "Standard test method for motor octane number of spark-ignition engine fuel," when vehicles are operated under conditions that correlate with road performance during highway driving conditions.

Octane number A measure of resistance to self-ignition (knocking) of a gasoline. The higher the octane number, the higher the anti-knock quality of the gasoline.

Olefins A class of hydrocarbons that have one double-bond in their carbon structure.

Oxygenates	Alcohols and ethers containing carbon, hydrogen, and oxygen. Oxygenates can be used as octane boosters or gasoline extenders.
Ozone	A colorless gas, it is an allotropic form of oxygen in which the molecule is O_3.
Reid vapor pressure	A standardized measure of a fuels volatility at a specified set of conditions, with a higher value indicating a more volatile fuel. RVP is usually measured in psi (pounds per square inch) or kPa (thousand pascals).
Research octane number	The octane value of a fuel, determined using the engine conditions defined in ASTM Standard D2699-97a, "Standard test method for research octane number of spark-ignition engine fuel," when vehicles are operated at low speed or under city driving conditions.
T50	The temperature at which 50 percent of the fuel evaporates.
T90	The temperature at which 90 percent of the fuel evaporates.
Tetraethyl lead	A compound that is used as a fuel additive to increase the octane value of gasoline.

Executive Summary

1 Under the framework of initiatives for Hemispheric Cooperation on Energy, and as part of the larger ESMAP/World Bank initiative to encourage elimination of lead from gasoline and to promote cleaner-burning fuels, a common set of the key technical specifications for major liquid fuels has been proposed for application throughout Latin America and the Caribbean. While it is the prerogative of individual countries to set national standards at levels they think appropriate, these proposed specifications are intended to provide guidance and, if implemented, could allow coherent regional product markets to develop. These standards are proposed as a baseline for all countries in the region, and it is recommended that they be implemented over the next seven years, with some interim targets set for 2001, and final standards targeted for 2005.

2 This study is the first in a series of initiatives aimed at addressing the issues related to changing fuels specifications in Latin America and the Caribbean. The study area included all of South and Central America, Mexico, and the majority of the Caribbean islands, excluding the U.S. protectorate states of Puerto Rico and the U.S. Virgin Islands. In developing the proposed specifications, the following sequence of activities was undertaken:

- A literature review of information previously collected on product specifications and laboratory test methods used in Latin America and the Caribbean was conducted, and an inventory of the specifications currently used in the region was developed.
- Current fuels standards in the United States and in Europe were analyzed to evaluate the direction and potential impact of international specifications.
- Draft specifications were developed that were believed to be achievable throughout the region, given the current complexity of refineries, state of the vehicle fleet, and environmental concerns.
- The proposed specifications were modified to reflect feedback from participants at two workshops, one held in Montevideo, Uruguay (September 1997), and the other in Quito, Ecuador (October 1997), to ensure that standards reflect regional views and are sensitive to regional differences.

3 Specifications of key parameters for gasoline, diesel, liquefied petroleum gas (LPG), and light fuel oil have been proposed, with special consideration being given to the local and national issues in the region. Issues considered when developing the specifications included investment requirements; effects on current vehicle fleet, current intraregional trade, and air quality; and sensitive geopolitical issues such as national supply security and the perspective of smaller/older refineries in some countries.

4 To ensure that the methodology to propose the specifications was rational, the project relied on the assistance of ARPEL (Asistencia Recíproca Petrolera Empresarial Latinoamericana) and several of its member companies' specialists. The specifications were also presented at two regional workshops where representatives from various countries reviewed the proposed standards and offered comments. To the extent possible, their recommendations have been incorporated into this report. These presentations were made to ensure that the proposed specifications were acceptable to, and would be implemented by, as many countries as possible.

5 Some countries may choose to set enhanced internal (region/city specific) or national (countrywide) standards when specific environmental concerns are a priority, but it has been concluded that standards proposed in this report would provide an achievable target in the short to medium term for most of the region. Specifications that are proposed in the report are presented in Table 1–Table 4.

Table 1 Proposed Specifications for Unleaded Gasoline

Specification	*Regular*	*Premium*
Research octane number (RON), minimum	91	95
Motor octane number (MON), minimum	82	85
Reid vapor pressure (RVP), psi, maximum	9.0 to 11.5	
T50, °C, maximum	120	
T90, °C, maximum	190	
Sulfur, wt ppm, year 2001, maximum	1,000	
Sulfur, wt ppm, year 2005, maximum	400	
Aromatics, vol%, maximum	45	
Olefins, vol%, maximum	25	
Benzene, vol%, maximum	2.5	
Oxygen, wt%, maximum	2.7	
Lead, g/l, maximum	0.013	

Note: Unless otherwise stated, the specifications should be applied by the year 2005.

Table 2 Proposed Specifications for Diesel

Specification	*Value*
Cetane number for year 2001, minimum	45
Cetane number for year 2005, minimum	47
T90, °C, maximum	360
Sulfur, wt ppm, year 2001, maximum	5,000
Sulfur, wt ppm, year 2005, maximum	2,000
Density, kg/m³ at 15°C	820–860
Aromatics, vol%, maximum	30

Note: Unless otherwise stated, the specifications should be applied by the year 2005.

Table 3 Proposed Specifications for Liquefied Petroleum Gas, 2005

Specification	*Propane*	*Butane/propane mixture*
Sulfur, wt ppm, maximum	140	140
Mixture	–	25–30% butane
C_5+, vol%, maximum	–	2
Butane+, vol%, maximum	2.5	–

Table 4 Proposed Specifications for Light Fuel Oil, 2005

Specification	*Value*
Sulfur, wt ppm, maximum	5,000

6 It is expected that intraregional trade will increase as common specifications eliminate one of the physical barriers to trade. In addition, the proposed specifications will promote use of cleaner-burning fuels and begin to address one of the factors contributing to emissions loading in many large urban areas. This report suggests that all fuels specifications proposed in the report be implemented throughout Latin America and the Caribbean over the next seven years.

7 In Latin America and the Caribbean, pollutants from the use of leaded gasoline are a contributor to pollution loads in large urban centers. This pollution problem has resulted in implementation of lead phase-out programs by many countries in the region. This report recommends the complete elimination of leaded gasoline

throughout the region by the year 2005. Countries that are only importers of gasoline should eliminate lead by 2001, with the remaining gasoline-producing countries limiting lead addition to 0.4 grams per liter (g/l) after 2001. One benefit of eliminating lead from gasoline is that it will encourage the continued use of catalytic converters on vehicles that have converters installed. Catalytic converters are the most effective means of reducing tailpipe emissions of hydrocarbons, carbon monoxide, and nitrogen oxides.

8 The specifications proposed in this study could have an impact on the Latin American and Caribbean economy. If the proposed standards are implemented as a baseline throughout the region, a number of smaller refineries may be unable or unwilling to make the investment necessary to enhance their production processes to comply with the more stringent proposed criteria. The overall effect is expected to be positive as regional economic efficiency improves through economies of scale, increased intraregional trade and productivity, and value added production from new investments.

1

Options for Fuels Specifications

Background

1.1 Under the framework of initiatives for Hemispheric Cooperation on Energy, an inventory of fuels specifications has been developed as part of a project designed to define common technical specifications for major liquid fuels. This project, entitled *Harmonization of Fuel Specifications in Latin America and the Caribbean,* addresses internationally recognized economic, trade, and environmental concerns. The study area included all of South and Central America, Mexico, and the majority of the Caribbean islands, excluding the U.S. protectorate states of Puerto Rico and the U.S. Virgin Islands.

1.2 Trade in Latin America and the Caribbean is being developed increasingly through several subregional associations such as MERCOSUR (Mercado Común de Sud América), CARICOM (Caribbean Community and Common Market), and the Andean Pact. These trading blocks demonstrate the desire of the countries to enhance the competitiveness of their economies. One of the goals of harmonizing fuels specifications is to encourage new suppliers to enter the marketplace. New suppliers of petroleum products could enhance trade opportunities and create a more competitive regional market.

1.3 The region is also attempting to improve the efficiency of its economy to enable individual countries to attract additional investment. The refining industry is one component of the economy that would benefit from increased investment. If fuels specifications can be harmonized, there would be a stronger incentive for investors to look at the refining and distribution sector of the Latin American and Caribbean region as an area of strategic expansion.

1.4 In addition to trade and economic reasons for participation in fuels harmonization, there is a need to respond to growing health and environmental concerns. Phasing-out lead in gasoline and a significant reduction of sulfur content in gasoline, diesel, and light fuel oils are among the major changes required in fuels specifications. These changes are being driven primarily by the more stringent air quality standards and general pollution control norms that are being adopted by an increasing number of countries in Latin America and the Caribbean.

Objectives of Study

1.5 The objectives of the *Harmonization of Fuels Specifications in Latin America and the Caribbean* study were to analyze the information that was previously collected on product specifications and laboratory test methods used in Latin America and the Caribbean and to prepare an inventory of their current status; analyze current international fuels quality standards to determine their direction and potential impact on the Latin American and Caribbean markets; and recommend regional fuels specifications that could be achieved before 2005. The focus of the study was on developing a set of minimum standards that would serve as an initial step toward the harmonization of regional fuels quality. The standards are set at a level that is achievable throughout the region, giving consideration to refining complexity and the industry's ability to make investments.

Regional Harmonization

1.6 The regional harmonization of fuels standards will affect individual countries differently. The ability of countries to realize import and export opportunities will vary, depending on the current structures of their petroleum industries. Countries that have large refiners and competitive production costs may find that they can expand into neighboring markets if all countries in the region demand fuels of similar quality. Smaller countries that are currently operating small (less efficient) refineries might realize economic benefits by being able to import a standardized product from a neighboring country instead of manufacturing refined products domestically.

1.7 Country-to-country transportation of fuels through pipelines in the region is beginning to expand. With the development of the Argentina-Chile and the Brazil-Bolivia pipelines, the exchange of energy commodities from one country to another is increasing. While refined products pipelines that cross national boundaries are still relatively rare, common fuels specifications for the region would increase opportunities for trade between countries, and especially the ability of countries to trade by pipeline.

1.8 This report focuses on the broad regional requirements for fuels quality and does not attempt to address every unique situation in the region. It recognizes that given areas may require specifications that will differ from the proposed regional standards, and that it is the prerogative of each country to determine if it needs to have unique standards for a particular area. Large urban enclaves are one example of locations that may need to have enhanced specifications to address local air quality problems.

Environmental and Health Benefits

1.9 The environmental and health benefits of improved air quality are well documented. Although environmental considerations are not the primary focus of this study, the standards being recommended in this proposal will result in cleaner-burning fuels. Cleaner-burning fuels can affect emissions in ways that will result in environmental and health benefits. It should be noted that, while improvements in fuels quality lead to lower pollutant emissions, their provision is only one of several actions governments can take to improve air quality. Modifications to vehicle exhaust systems, changes in engine design, development or improvements of public transportation systems, improvements to transportation infrastructure, and vehicle inspection and maintenance programs should all be considered as tools to control vehicle emissions, air quality, and environmental and health conditions.

1.10 One of the more significant pollutants in gasoline is lead additives, such as TEL (tetraethyl lead), which are used to enhance the anti-knock characteristic of fuels. As part of this project, a time line for the phase-out of leaded gasoline has been developed for implementation by the year 2005.

1.11 Because lead residues in the environment are poisonous to humans and lead anti-knocks in gasoline are by far the largest source of lead residue, eliminating leaded gasoline could yield significant health benefits. Lead residues also contribute—although generally only to a small extent—to an increase in particulate emissions.

1.12 Other changes to fuels specifications have varying effects on emissions and a variety of effects on health and the environment. For gasoline, the following general effects can be expected:

- **Reduced RVP**: Lessens evaporative and refueling emissions, especially from older vehicles that do not have evaporative control equipment.
- **Reduced T50:** (temperature at which 50 percent of a fuel evaporates): Generally lowers emissions. Reductions are limited to vehicles with carburetors.
- **Reduced T90**: Generally lowers hydrocarbons and PM_{10} (particulate matter with an aerodynamic diameter of 10 microns or smaller) emissions. Sometimes leads to increased CO (carbon monoxide) emissions.
- **Reduced sulfur**: Reduces hydrocarbons, CO (carbon monoxide), and NO_x (oxides of nitrogen) in vehicles with three-way catalytic converters; reduces SO_2 (sulfur dioxide) and PM_{10} in all vehicles. Sulfur is a poison to three-way catalytic converters.
- **Reduced benzene:** Reduces benzene emissions, and possibly NO_x.
- **Allowing oxygenates**: Reduces CO emissions, particularly in older vehicles. Reduces the need for large amounts of aromatics to achieve high octane.

- **Reduced aromatics**: Reduces NO_x, reactivity of fugitive emissions and benzene emissions.
- **Reduced olefins**: Reduces the formation of ground-level ozone, NO_x emissions.

1.13 For diesel, the following general effects can be expected:

- **Increased cetane**: Requires lower aromatic content, unless cetane is increased by using cetane additives. Can increase engine efficiency up to a certain level. Reduces the emissions of hydrocarbons, CO, No_x, and/or PM_{10} in some cases.
- **Reduced sulfur**: Reduces SO_x and particulate emissions.
- **Reduced T90**: Improves cold starting. Reduces the emissions of $PM_{10.}$ Reduces polynuclear aromatics.
- **Reduced aromatics**: Reduces soot formation and PM_{10} emissions.

1.14 For LPG and light fuel oils, the following general effects can be expected:

- **Reduced sulfur**: Reduces SO_x and particulate emissions.

Market Realities

1.15 Although the Latin American and Caribbean market is continuing to expand, there are a number of factors that will make it difficult to expand the intraregional trade of petroleum products. The limited complexity of refineries in the region, inadequate distribution/transportation systems, large number of small-capacity (less than 50,000 barrels per day, b/d) refineries (which exist to supply domestic markets, but would have difficulty competing in an open market), and the nonuniformity of current fuels specifications all create obstacles to trade. These factors must all be considered as the specifications are developed.

1.16 As Latin America and the Caribbean move toward harmonized fuels standards, it is important to consider what has already been achieved in other areas of the world. Issues such as the requirement of new vehicles currently sold in the United States and Europe for higher-quality fuels must be considered, because these vehicles will eventually become common in Latin America and the Caribbean. As these vehicles make their way into the market, their requirements for higher-quality fuels will need to be addressed.

1.17 While the region's market growth may generally follow international trends, caution should be used when comparing its petroleum use with that in other areas of the world. The Latin American and Caribbean market uses a higher proportion of diesel to supply its transportation fuels needs than many other markets. This alters the refining problems and limits the application of solutions that are appropriate in other regions.

Significance of U.S. Standards

1.18 The United States has established itself as a world leader in the development and implementation of reformulated fuels programs. In the United States, the Environmental Protection Agency (EPA), and particularly the California Air Resources Board (CARB), have introduced specifications for gasoline that are among the most stringent in the world. Table 1.1 and Table 1.2 list some U.S. gasoline (reformulated gasoline program, phase I simple model) and diesel standards. Because the U.S. market for gasoline is also the largest market in the world, U.S. EPA standards might influence the quality of gasoline in the Caribbean and in some Central and South American countries.

Table 1.1 U.S. Gasoline Specifications

Specification	*Phase I (simple model)*	*ASTM*
(RON+MON)/2	87	87
RVP, psi, summer maximum	7.2 or 8.1	7.8–15.0
T90, °C, maximum	No greater than the average values in each refiner's 1990 gasoline (industry average, 166)	190
Oxygen, wt%, minimum	2.0	–
Sulfur, wt ppm, maximum	No greater than the average values in each refiner's 1990 gasoline (industry average, 339)	1,000
Benzene, vol%, maximum	1.0	–

Table 1.2 U.S. Diesel Specifications

Specification	*U.S. (ASTM)*	*CARB (reference diesel)*
Cetane	40 (number)	48 (number)
T90, °C, maximum	338	320
Sulfur, wt ppm, maximum	500	500

1.19 North American refineries are relatively complex. This complexity has been partly driven by the introduction of very stringent fuels specifications. Several large export-based Caribbean refineries have also become fairly complex, because the United States is a major market for their exports. Refineries in Mexico, the Netherlands Antilles, and Venezuela have varying degrees of complexity, but they all have sufficient complexity to export some product to the United States. Trends toward large regional trading blocks such as NAFTA (North American Free Trade Agreement) may also affect the Latin American petroleum refining industry.

European Fuel Strategy

1.20 The European Union (EU) has also been active in proposing gasoline and diesel formulation standards aimed at reducing pollutant emissions from vehicles. European standards for gasoline have tended to follow U.S. specifications, although there is often a time delay between implementation in the United States and in the EU. This delay is partly a result of the multicountry structure of the EU, which slows the establishment of new standards because agreement among numerous countries is difficult and time consuming. European standards for diesel have often led the U.S. regulatory effort, because diesel plays a more prominent part as an automotive fuel in Europe than it does in the United States.

1.21 EU specifications proposed for the years 2001 and 2005 will be progressively more stringent. Table 1.3 and Table 1.4 list proposed European standards for gasoline and diesel. There is considerable discussion among European refiners about how they will meet the new fuels standards, particularly those proposed for 2005.

Table 1.3 Proposed EU Gasoline Specifications

Specification	*European Commission, 2000*	*European Parliament, 2000*	*European Parliament, 2005*
RON, minimum	95		95
RVP, psi, maximum	8.7		~8
Sulfur, wt ppm, maximum	200	50	30
Benzene, vol%, maximum	2.0	1.0	

Table 1.4 Proposed EU Diesel Specifications

Specification	*European Commission, 2000*	*European Parliament, 2000*	*European Parliament, 2005*
Cetane number, minimum	51		58
T95, °C, maximum	360		340
Sulfur, wt ppm, maximum	350	100	50

1.22 Approximately 18 percent of world refining capacity is located in Western Europe. Demand for refined products is expected to grow at a modest rate. Increasingly stringent standards for sulfur and increased diesel cetane will place pressure on the existing refineries. The current European situation may mirror the circumstances of the Latin American and Caribbean refiners in the year 2005, both in the demands on refineries and the multicountry political structure. It would be useful for the Latin American and Caribbean region to monitor the EU as it moves toward more restrictive fuels specifications.

2

Rationale for Harmonization

Harmonization and Trade

State of Existing Fuels Standards

2.1 The Latin American and Caribbean region is one of diverse geographical, political, and social conditions. The region comprises forty countries spread over two continents, which vary from the very large (such as Brazil, with over 8 million km^2 and 150,000,000 people) to the very small (such as Anguilla, with an area of less than 100 km^2 and 7,000 residents). There is a wide variety of national fuels specifications among this diverse group of states.

Table 2.1 and Table 2.2 provide an overview of the variety of specifications that currently exists in the region. (A survey of specifications in the region is included in the Annex.)

Table 2.1 Current Range of Latin American and Caribbean Gasoline Standards

Specification	*Lowest value, regular*	*Highest value, regular*
RON	80	93
RVP, psi	8.4	12.0
T50, °C	100	140
T90, °C	190	210
Sulfur, wt ppm	500	2,500
Benzene, vol%	0.5	5.0

Table 2.2 Current Range of Latin American and Caribbean Diesel Standards

Specification	*Lowest value*	*Highest value*
Cetane index	40	48
T90, °C	338	370
Sulfur, wt ppm	500	10,000

Market Growth

2.2 The current regional refining capacity is 6.4 million barrels per calendar day, and the utilization rate is nearly 80 percent. Overall demand for liquid transportation fuels in Latin America and the Caribbean will continue to increase by 2–3 percent annually over the next seven years. This estimated growth rate is based on the assumption that some barriers to trade continue to impede the free flow of goods and services within the region, so that growth in fuels demand will follow historic growth patterns. There is a possibility that the establishment of larger trading blocks will enhance economic growth.

Security of Supply

2.3 Countries that do not have a sufficient domestic supply of fuels will have an increased number of regional supply sources if a standardized set of specifications can be implemented.

Regional Trading Blocks

2.4 The current global direction is toward larger strategic trading blocks. The largest is NAFTA, which has a significant influence on the northern Latin American and Caribbean countries. Regionally, Latin America and the Caribbean countries are beginning to align themselves into trading groups. MERCOSUR, the Andean Pact, and CARICOM are three examples of the trend. As infrastructure improves, countries will look more closely to neighbors as potential trading partners. The presence of large trading blocks will provide a logical framework for future adjustments to Latin American and Caribbean fuels specifications.

Barriers to Harmonization

2.5 There are currently both physical and political barriers to the trade in fuels among countries in Latin America and the Caribbean. This study focuses on one physical barrier to trade—fuels specifications. Some of the social and political barriers to achieving harmonized fuels specifications must be acknowledged, and they were given due consideration as achievable standards were defined.

Role of Energy in National Economies

2.6 A constant supply of energy is a key ingredient for any economy; therefore, the security of that supply is extremely important to governments. One conclusion that may be drawn from this study is that some of the smaller refineries are not economically efficient, and the best economic decision would be to close those refineries and import fuels instead of making the investment necessary to meet enhanced quality requirements. The closing of domestic refinery capacity and the importing of fuels from neighboring countries places some of the control of the supply of energy to the local economy in foreign hands. As new fuels specifications are proposed, the sensitivity of governments to losing some control over their supply of energy must be considered.

Supply Security—Perception and Reality

2.7 Crude oil is generally considered as an international commodity that can be bought and sold easily on the world market. Refined products such as gasoline and diesel are not generally recognized as equally available commodities, and this creates a perception that it is more difficult to buy those products on the international market. This is the view in many countries, and there is a tendency for Latin American countries to be willing to import crude, but less willing to import refined products such as gasoline and diesel. This tendency will not change quickly, but harmonization of specifications will help to minimize concerns by providing more supply sources.

Crude Export Product Import Sensitivities

2.8 For countries that have some level of petroleum exploration and production in place, the preference will be to avoid exporting crude and importing refined products. Although this may be the most efficient means of supplying refined products to the domestic market, countries have implemented barriers (taxes, specifications, tariffs) that make refining their own crude appear more attractive.

Environmental Overview

2.9 Increased public awareness of pollution problems and their sources has led to pressure being placed on governments to improve environmental conditions, especially in large urban centers. Improvements in fuels quality is one course of action that local governments can take to address air quality problems.

2.10 The environmental and health benefits of improved air quality are well documented. Although environmental considerations are not the primary focus of this study, the standards recommended in this proposal will result in cleaner-burning fuels.

Lead Issues

2.11 In urban areas, a significant portion of lead emissions to the atmosphere derive from vehicular traffic. This lead residue tends to remain close to the source and will often accumulate along roadsides and near major motorways. In some large urban centers, people live and work in close proximity to major motorways, and are thus exposed to elevated levels of lead residue.

2.12 Lead in the environment is poisonous to humans, and the combustion of lead anti-knock additives in gasoline is one of the significant sources of lead residue in urban centers. The health effects of elevated levels of lead in the blood include reduced mental capacity in children and high blood pressure in adults. The elimination of leaded gasoline would reduce the amount of lead residue added to air, water, and soil. It would also reduce particulate emissions, although only to a small extent in most cases.

Other Environmental Considerations

2.13 The fuels specifications proposed in this report will provide positive environmental benefits in addition to the potential trade benefits. Nevertheless, eliminating lead without applying appropriate restraints on unleaded gasoline will reduce benefits.

2.14 The most important change to gasoline quality will be the elimination of lead. In addition, reductions in the emissions of hydrocarbons, CO, So_x, and NO_x can be expected with the proposed cleaner-burning gasoline. PM_{10} is generally considered one of the most serious air pollutants in Latin America, but new fuels standards should help decrease the vehicle fleet's contribution of this pollutant.

2.15 Specific vehicle fleet information is available from several sources. A draft report was completed recently as part of the ARPEL/CIDA environmental program phase 2. The report, *Vehicular Technologies and Emissions*, provides an overview of vehicle issues related to emission levels.

2.16 The diesel specifications being proposed will begin to address the pollution problems stemming from high-sulfur diesel. Although the specifications do not recommend very low sulfur levels, they will require many countries that are currently producing diesel fuel to begin limiting the sulfur content of their product.

Lead Phase-Out

2.17 Lead additives have been used in gasoline since the 1920s to enhance the anti-knock characteristics of gasoline. Over the past twenty-five years, awareness of the environmental and health risks associated with the combustion of leaded gasoline has increased. In Latin America and the Caribbean, air pollution from the use of lead in gasoline has become a key consideration in the overall effort to improve air quality in large urban centers. One of the more significant pollutants in gasoline is lead additives. Lead phase-out programs have been completed in several countries in Latin America, and programs for phase-out have been announced in several others.

2.18 Of the countries that propose to continue selling leaded gasoline beyond 2005, Venezuela will be the largest user of lead additives. If plans can be developed in Venezuela for the elimination of lead from gasoline by the year 2005, Latin America and the Caribbean would become a virtually lead-free region (less than 5 percent leaded gasoline consumption).

Technical Issues

2.19 As countries around the world have eliminated leaded gasoline, there has been some concern regarding the effect of unleaded gasoline on the soft valve seats of engines. Numerous studies have been conducted on the topic, and the findings have generally indicated that the potentially detrimental effects of eliminating leaded gasoline appear to have been greatly exaggerated, while the potentially beneficial effects have been either understated or ignored. Alarm over the effects of the change from leaded gasoline to unleaded gasoline on old model cars (manufactured before 1970) has little foundation. Therefore, there is no justification for delaying the implementation of programs for the elimination of lead in gasoline on this basis. Countries such as Brazil, Colombia, Honduras, and Guatemala have eliminated lead from gasoline without any reports of problems with the older model cars in their vehicle fleets.

Environmental Benefits

2.20 The elimination of leaded gasoline would reduce the amount of lead residue in air, water, and soil, as well as emissions of particulate material (PM_{10}). Because particulate emissions are often identified as one of the most serious air pollutants in large urban areas, there would be environmental and health benefits from their reduction.

2.21 The health risks associated with lead exposure include elevated blood pressure levels in adults and reduced mental capacity in children. The demands placed on scarce social, health care, and education resources by these conditions can be substantial.

2.22 A significant benefit of phasing-out leaded gasoline and introducing unleaded gasoline is that it allows the use of catalytic converters. Catalytic converters are the most effective means of reducing hydrocarbons, NO_x, and CO emissions from vehicles.

2.23 The availability of low-priced leaded gasoline acts as a deterrent to the use of unleaded gasoline and, therefore, the use of catalytic converters. As part of their plans to phase out lead, countries may have a transition period during which both leaded and unleaded gasoline are available. In cases where leaded gasoline is sold at a lower price than unleaded, however, experience has shown that the availability of lower-priced leaded gasoline encourages owners of vehicles with catalytic converters to refuel with leaded gasoline, even though misfueling with even one tank of leaded gasoline can seriously damage catalytic converters. A number of European countries have successfully adopted the policy of reducing the tax on unleaded gasoline to make its price to the consumer lower than that of leaded gasoline. Such a policy measure facilitates the transition from leaded to unleaded gasoline.

Refinery Impacts

2.24 The addition of lead additives is an inexpensive way to increase the octane value of gasoline. The elimination of lead will force refineries to replace the lost octane. There are a number of options that individual refineries may evaluate as they plan for the phase-out of lead additives, including:

- Purchasing other octane-enhancers such as methyl tertiary butyl ether (MTBE)
- Modifying current refinery processes to create more octane-blending components
- Upgrading refinery process units.

2.25 In most cases, refiners will need to make investments in their refineries. This may prove to be uneconomic, depending on the size and complexity of the facilities. For some of the smaller refineries, the best option may be to close the local refinery and import products from facilities with larger, more complex refining infrastructure.

Phase-out Programs Already in Place

2.26 There are currently fourteen countries in Latin America and the Caribbean that have eliminated leaded gasoline. On a volume basis, less than 30 percent of the gasoline currently consumed in the region is leaded. There are an additional nine countries that have programs in place to eliminate lead by the year 2005. By that time, about 10–15 percent of the gasoline consumed in the region will be leaded. Of this amount, much of it will be in the Venezuelan market. Cuba and Venezuela are the only countries in the region that have not yet made unleaded gasoline available.

2.27 Table 2.3 provides a list of the countries that had eliminated leaded gasoline by 1997 and those that will eliminate leaded gasoline by the years 2001 and 2005.

Table 2.3 Lead-free Countries in Latin America and the Caribbean

Country	*1997*	*2001*	*2005*	*Comments*
Antigua & Barbuda	lead-free	lead-free	lead-free	
Argentina	lead-free	lead-free	lead-free	
Bahamas	lead-free	lead-free	lead-free	
Barbados		lead-free	lead-free	lead removal in 2000
Bermuda	lead-free	lead-free	lead-free	
Bolivia	lead-free	lead-free	lead-free	
Brazil	lead-free	lead-free	lead-free	
Chile				no date set
Colombia	lead-free	lead-free	lead-free	
Costa Rica	lead-free	lead-free	lead-free	
Cuba				
Dominican Republic		lead-free	lead-free	lead removal by 1/1/99
Ecuador		lead-free	lead-free	lead removal by 1/1/2001
El Salvador	lead-free	lead-free	lead-free	
Guatemala	lead-free	lead-free	lead-free	
Haiti		lead-free	lead-free	lead removal by 1/1/99
Honduras	lead-free	lead-free	lead-free	
Jamaica		lead-free	lead-free	lead removal by 1/1/2001
Mexico		lead-free	lead-free	lead removal in 1999
Netherlands Antilles				no plan for lead removal
Nicaragua	lead-free	lead-free	lead-free	
Panama		–	lead-free	considering lead removal by 2001
Paraguay		lead-free	lead-free	considering lead removal by 1/1/2000
Peru				considering lead removal by 2005
Saba	lead-free	lead-free	lead-free	
St. Eustasius	lead-free	lead-free	lead-free	
Trinidad & Tobago		lead-free	lead-free	lead removal by 6/2000
Uruguay				no date set
Venezuela				
Total lead-free	14 countries	22	23	

Guideline for Lead Phase-out

2.28 The current specifications for leaded gasoline vary substantially from country to country. This variation appears to be driven largely by constraints in domestic production, and less so by any analytical approach to specifications setting.

2.29 Programs for the complete phase-out of leaded gasoline will vary depending on the circumstances in each country. Countries must evaluate their gasoline market and create programs for lead elimination based on their situations. Programs will vary depending on whether the countries are pure importers of gasoline or must adapt internal refining operations to produce unleaded gasoline.

2.30 It is proposed that countries that are exclusively importers of gasoline eliminate all lead from gasoline by the year 2001. It is further proposed that countries that have refining capacity and still produce leaded gasoline completely phase-out leaded gasoline by the year 2005 if they do not have programs in place to eliminate lead before that date. The phase-out of lead will take some time in countries that have not yet formalized their lead phase-out programs, because investment will be needed to upgrade existing facilities or build new units that can produce unleaded gasoline that complies with the proposed specifications.

2.31 Lead additives are used to increase the octane value in gasoline. Nevertheless, there are diminishing returns to this process: as more lead is added to gasoline, there are smaller and smaller increases in the octane value. As a result, reductions in the amount of lead used from high levels (0.6 or 0.8 g/l) to more moderate levels (0.4 g/l) will not result in large losses in octane value. It is proposed that countries that cannot phase-out lead until 2005 reduce their maximum lead concentration to 0.4 g/l by the year 2001.

2.32 One consideration for countries that delay the phase-out of lead is that there will be a point when lead additives simply will not be available in the marketplace because regional demand is too low. Suppliers of lead additives will not continue to supply TEL to the Latin American and Caribbean market at an affordable price because it will be uneconomic. That break-even point has not been precisely identified, but smaller fuels producers will be particularly vulnerable as leaded gasoline production drops.

2.33 All countries should consider implementing public education programs that illustrate the benefits of eliminating lead from gasoline. It is likely that the introduction of unleaded gasoline will mean a higher price at the pump for consumers. If consumers have not been informed of the positive benefits of the change, they may be reluctant to pay the higher price for their fuel.

3

Fuels Specifications

Gasoline

Global and Regional Direction

3.1 Gasoline specifications are changing worldwide as regulatory constraints are imposed. Regulators are using two primary methods to control emissions. One is to force vehicle manufacturers to produce vehicles that emit fewer pollutants. The equipment that the manufacturers are using requires cleaner-burning fuels, and this is forcing fuels producers to upgrade their product. The other method is to directly regulate fuels quality in an effort to reduce emissions from fueling facilities and vehicles.

3.2 Two of the most aggressive regulators of gasoline are the United States Environmental Protection Agency (U.S. EPA) and the California Air Resources Board (CARB). Other regions of the world also have very aggressive programs in place or under consideration.

3.3 In Latin America and the Caribbean, individual countries are addressing many fuel quality concerns, but the only gasoline issue that has received widespread attention is the phasing-out of leaded gasoline. MERCOSUR has had some discussions on harmonization of fuels specifications, but to date has not arrived at any agreement.

3.4 Several countries in Latin America and the Caribbean meet multiple gasoline standards because they export a portion of their product, particularly to the United States, and sell a lower-quality domestic product in their own country.

Technical Issues

3.5 The major driving force affecting fuels specifications are the changes forced on the fuels industry by the vehicle manufacturers as they redesign their vehicles to meet enhanced emission targets. Changes are also being pressed on the fuels manufacturers as they meet the regulatory changes imposed on them directly.

3.6 Since vehicle manufacturers tend to use many of their designs worldwide, design changes made for the most regulated markets influence the fleet of vehicles in the least regulated market. This tendency is forcing fuel quality changes, even in markets with an absence of regulation. Fuels standards imposed by direct regulation of the fuels industry tend to reflect national priorities and can differ markedly from country to country.

3.7 In developing a proposal for Latin American and Caribbean gasoline specifications, it was concluded that the standards most critical to fuels quality and fuels harmonization were the octane level of the fuel (RON and MON), vapor pressure, distillation range (T50 and T90), sulfur level, and benzene content. It was also concluded that a maximum oxygen level should be recommended, and some comments should be provided on the amount of total aromatics and olefins. While there are many other parameters that are important in the production of quality gasoline, some degree of harmonization on these parameters will provide an essentially consistent product throughout the region.

3.8 For octane, sulfur content, oxygen content, and distillation range, the evaluation of acceptable parameters was primarily an evaluation of the vehicle issues. While these fuel parameters have some direct impact on emissions, vehicle technology was considered the primary concern in the Latin American and Caribbean market. As representative vehicles in the vehicle fleet move from the models of the early 1980s to those of the late 1990s, octane, sulfur, oxygen, and distillation range standards may need to become increasingly stringent.

3.9 For gasoline vapor pressure and benzene content, as well as consideration of total aromatics and olefins, the issue was primarily environmental. Benzene has been well established as a carcinogen, and certain aromatics compounds contribute to ozone formation. Reducing vapor pressure to a level that still allows acceptable vehicle performance reduces emissions of volatile organic compounds. Olefins are ozone precursors and, in addition, contribute to poor fuel stability.

Refinery Impacts

3.10 The manufacture of unleaded gasoline requires blending naturally occurring ("straight-run") gasoline of relatively low-octane with high octane gasoline components that are produced from the chemical conversion of straight-run gasoline or heavier fuel streams.

3.11 A large portion of the gasoline produced in Latin America and the Caribbean is manufactured from the straight-run gasoline components because gasoline demand has been limited and the addition of TEL as a blending component has allowed the production of leaded gasoline with limited capital investment. In some locations, low-octane leaded gasoline has been produced by merely adding lead to the straight-run components, with no additional processing.

3.12 For simple refineries, the least capital-intensive method of producing unleaded gasoline is to isomerize the light straight-run gasoline components, reform the heavier straight-run portion of the crude, and add purchased high-octane blending components to meet the product's octane specification. This often results in a gasoline that is high in aromatics.

3.13 More complex refineries will have, in addition to the reformer and isomerization units, some combination of catalytic cracking, alkylation, polymerization, hydrocracking, and ether production units to provide blending components to the gasoline pool. Combining these technologies will allow the refiner to meet not just the octane standard, but all of the parameters of the specifications for a high-quality gasoline product. The requirement for these capital-intensive processes, however, will favor the larger refiner and make it difficult for the smaller operator to remain competitive.

Proposed Vapor-Pressure Standard

3.14 The gasoline Reid vapor pressure (RVP) in the region averages approximately 10–10.5 psi when the variety of specifications among the countries is considered, and 9.5-10 psi on a volume-average basis. While this vapor pressure average is not an unreasonable value for the region, the maximum allowable pressure varies significantly from country to country, and there is no consistency across the region.

3.15 Because the Latin American and the Caribbean region encompasses an extremely diverse climatic area, there is no one value that is appropriate for gasoline vapor pressure throughout the region. Further, in regions where there is significant seasonal variation in temperature, there will be a requirement for the vapor pressure of the gasoline to change from season to season.

3.16 It is proposed that the vapor pressure target for the hottest tropical regions be reduced to 9 psi, and that the vapor pressure in other markets be established in a manner consistent with the methodology developed and presented by the American Society for Testing and Materials (ASTM D4814-96, "Standard Specification for Automotive Spark Ignition Engine Fuel or Its Equivalent"). Using this methodology, Latin America and the Caribbean would be divided into five regions, as shown Table 3.1. Each region would have a summer vapor pressure that would reflect its climatic requirements. The summer vapor pressure would then be modified seasonally, as shown in Table 3.1. As specific vapor pressure levels are set, national governments should recognize that reducing vapor pressure in gasoline is one of the most cost-effective ways of reducing overall hydrocarbon emissions, including toxics such as benzene.

Table 3.1 Proposed RVP Zones and Maximum RVP

Zone	*Summer*	*Winter*
Central America, Caribbean, Venezuela, Guyana, and Amazonian region of Peru, Bolivia, Colombia, and Brazil	9.0 psi	9.0 psi
West Coast of Colombia, Ecuador, Peru, and some parts of Central America	9.0 psi	10.0 psi
Southeast Brazil, Paraguay, Uruguay, and northeast Argentina	9.0 psi	10.5 psi
Andean subregion including high-altitude areas of Colombia, Peru, Bolivia, northern Chile, and northern Argentina	9.5 psi	11.0 psi
Southern Chile and southern Argentina (Patagonia)	10.5 psi	11.5 psi

3.17 The above proposal is intended to provide guidance in establishing the general profile of the climatic regions; it is not meant to be the final determination of the dividing lines between vapor pressure classes. It is recommended that national governments give consideration to distribution logistics as they determine the boundaries of vapor pressure standards zones. At that time, more detailed local maps should be developed that allow consideration of both the climatic data and the supply logistics for each market. The vapor pressures proposed in Table 3.1 should meet the general needs of the region. Urban areas that have unique environmental concerns may determine that it is necessary to establish more restrictive specifications.

Proposed Octane Standard

3.18 Most vehicles require a minimal octane threshold to operate efficiently, and there is no advantage to burning a fuel with an octane level above the required minimum. The petroleum industry, however, has provided gasoline at several octane grades to the market for many years, and it is expected that this strategy will continue to dominate marketing plans.

3.19 A review of octane requirements for adequate performance suggests that two octane grades will supply the needs of virtually the entire market: a "regular" grade, which will meet the needs of most of the vehicle fleet, and a "premium" grade, which will meet the requirements of the higher-compression engines. The proposal presented here provides specifications for both of these products.

3.20 While many of the older vehicles that burn leaded gasoline could accept low-octane gasoline with minor adjustments, the fuel-injected, computer-monitored vehicles currently being marketed are standardized to higher fuel quality. Most of today's vehicles are designed for a fuel with a minimum motor octane number of 82 and a research octane number of 91–92. It is proposed that the region standardize the minimum octane level for regular gasoline at 91 RON and 82 MON.

3.21 The proposed octane standards will meet the needs of most of the new vehicles entering the market. While some older vehicles may have other fuels requirements—lower octane requirements for certain low-compression engines and higher octane characteristics for high-compression, small-displacement engines—essentially all of the Latin American and Caribbean vehicle fleets in the year 2005 will perform adequately with the proposed fuels.

3.22 Although the majority of vehicles will perform adequately on the proposed regular gasoline, there is a need for higher-octane (premium) gasoline for high-performance engines. Standards have addressed the requirements of higher-performance engines by moving toward a RON of 95 and a MON of 85 for premium gasoline blends. It is proposed that the specification for premium gasoline be established at 95 RON and 85 MON.

3.23 Octane levels in higher altitudes have tended to be lower than those in the lower-altitude markets. While lower-octane fuels are acceptable at higher altitudes when the fuel is being used in older vehicles, newer vehicles with computer-controlled fuels systems are designed to operate at the same octane, regardless of altitude. As this newer kind of vehicle increases its market share, the acceptability of low-octane fuels will diminish. For this reason, no altitude differentiation is proposed in this octane specification.

Proposed Sulfur Standard

3.24 Gasoline sulfur levels are becoming a significant concern as more sophisticated catalytic converters enter the marketplace. While cars with catalytic converters are not a large part of the Latin American and Caribbean fleet today, catalytic converters are a prominent part of many countries' emission control programs, and they will have an increasingly significant position in the market in future years.

3.25 Some vehicle manufacturers have suggested a maximum fuel sulfur level of 80 wt ppm (parts per million by weight) for optimal long-term catalytic converter performance, but this low sulfur level will not be achievable in the Latin American market without very significant investment.

3.26 It is proposed that gasoline sulfur be limited to 1,000 wt ppm in the year 2001 and to 400 wt ppm by the year 2005 to assure successful long-term performance of catalytic converters. This level will not force most refiners to remove sulfur from gasoline produced in the catalytic cracking unit.

Proposed Distillation Standard

3.27 Distillation standards have traditionally been set at levels that provide for good vehicle performance. Recently, however, there has been more interest in setting lower distillation targets to reduce emissions of undesirable contaminants.

3.28 In Latin America and the Caribbean, the current range of values for the distillation control point is quite wide. T50 (temperature at which 50 percent of fuel evaporates) ranges from 100 to 140°C and T90 ranges from 190 to 210°C. It is proposed that distillation standards for the year 2005 be set at the following:

T50 120°C maximum

T90 190°C maximum.

These levels will have little impact on the industry, but they will allow standardization of fuels across the region.

Proposed Benzene Standard

3.29 Most Latin American and Caribbean countries have established specifications that allow up to 5 percent benzene in gasoline. This is much higher than the actual 2–3 percent benzene content reported for fuels in the region. Benzene specifications in several countries are being reduced to levels of less than 1 percent to address concerns about the carcinogenic effects of benzene.

3.30 While there is continuing debate over the best guidance for handling airborne benzene, it appears to be prudent to ensure that the actual benzene content in gasoline not increase above current levels as refiners switch from leaded to unleaded gasoline production. For this reason, it is proposed that the benzene level in gasoline be limited to 2.5 percent by volume (vol%). Some refineries in the region may have difficulty meeting this specification.

Oxygenates

3.31 Ethers and other oxygen-containing hydrocarbons can be an excellent source of gasoline octane, and their use reduces the requirement for aromatics to make up octane deficiencies. In addition to the octane benefits, oxygen-containing compounds will reduce the amount of CO emitted by older vehicles. Most Latin American and Caribbean gasolines, with the exception of gasolines sold in Brazil, do not contain any oxygen, and few countries have any specifications for the use of oxygenates.

3.32 It is proposed that a maximum oxygen level of 2.7 percent by weight (wt%) be allowed in gasoline to encourage refiners to consider the use of ethers as part of their gasoline pool. Urban environments that have particular ground-level ozone problems may mandate minimum oxygen contents in gasoline for their individual markets. The cost of a standard of this nature for all gasoline is not justified, but it may be a cost-effective approach for selected isolated markets.

3.33 Some countries have made a decision to blend significant quantities of ethanol into their gasoline. These programs may have national applications, but they are not considered to be appropriate on a regional basis.

Aromatics

3.34 It is recommended that total aromatics in gasoline be limited to 45 percent of the gasoline blend. This standard is higher than the limits being discussed in some jurisdictions, but it will allow the Latin American and Caribbean refining industry some flexibility in how they manufacture gasoline, while ensuring that aromatics are not used as the primary method of producing octane when leaded gasoline is eliminated.

Olefins

3.35 High olefin content in gasoline will compromise gasoline stability and make it more difficult to meet gasoline stability tests. For this reason it is recommended that olefins content in gasoline be limited to a maximum of 25 percent.

3.36 Some jurisdictions regulate olefins because they are highly reactive in the atmosphere, particularly in their contribution to ground-level ozone. This contribution is most intense within a short radius from the source. It may be necessary for urban areas with serious ozone problems to mandate olefin specifications that are more restrictive than those proposed in this report.

Lead Content in Unleaded Gasoline

3.37 As countries convert distribution systems from leaded to unleaded gasoline, the opportunity for cross-contamination of gasoline must be considered. Such lead contamination can cause deterioration of catalytic converter performance. It is proposed that a maximum level of lead in unleaded gasoline be set at 0.013 g/l. This level is consistent with standards established in other parts of the world.

Diesel

Global and Regional Direction

3.38 Diesel fuel is under intense scrutiny worldwide as vehicle manufacturers improve vehicle operation and as increasingly strict emissions limits are implemented. European diesel standards are generally more restrictive than North American standards because diesel-powered vehicles are more prevalent in the European market. North American diesel standards have tended to focus on diesel sulfur levels, and less on fuels cetane level, but all standards are under review as engine technology evolves. Overall, markets are proposing higher cetane values, a lower distillation endpoint, and reduced sulfur levels. It is expected that this trend will continue, and proposals currently being discussed in Europe indicate that diesel fuel will have undergone substantial changes by the year 2005.

3.39 In Latin America there is considerable diversity in specifications and in the quality of the marketed product. This diversity of specifications makes product trading difficult, and availability of suitable fuels is a problem for some cross-border travelers. This will become a more acute problem as the liberalization of Latin American and Caribbean markets creates more cross-border trade and greater movement of goods.

Technical Issues

3.40 Standards for diesel did not receive the same attention as those for gasoline until quite recently. As a result, changes in diesel standards are only now being debated globally, and it is still unclear what fuels will be required by future vehicles.

3.41 The issues that are clearly important are cetane level, T90, and sulfur. While there are many other diesel specifications that characterize a fuel, and must be specified to ensure consistent quality in the diesel product, the standards discussed in this proposal will generally ensure reliable fuels quality. The one major specification that is not addressed, however, is the low-temperature flow characteristics of fuels. The specification is more appropriately set at the national level.

3.42 The considerations for cetane number are the fleet needs and the direction that engine manufactures will take as they strive to meet increasingly stringent engine-performance standards. The distillation range must be evaluated from a technical and environmental perspective. There is also a significant concern about the commercial impact of reducing T90. The sulfur level is considered as an environmental issue primarily because it affects particulate emissions.

Refinery Impacts

3.43 The refinery must change its distillation operation if it is required to produce diesel with a lower T90 temperature. This can create refinery bottlenecks, but the greater problem is that more crude must be run for the same diesel output. This is a significant concern in the Latin American and Caribbean market, where diesel represents a very large portion of the transportation fuels demand.

3.44 The diesel from catalytic cracking units is low in cetane. Since catalytic cracking has been the most popular technology for upgrading heavy fuels oil to higher-value products, any change in specifications that contemplates increasing the cetane requirements will force substantial changes on many refineries. The removal of sulfur increases the need for hydrotreating, which can force extensive investment if extremely restrictive specifications are enforced.

Proposed Cetane Standard

3.45 The cetane index for diesel sold in Latin America and the Caribbean varies from 40 to 48. Most countries in the region have a specification of a 45 cetane index. As a result of the emphasis on emissions and the ongoing concern of engine manufacturers about the cetane requirements for their engines, it is proposed that the cetane standard for the region be set at a 45 cetane number in 2001 and a 47 cetane number by the year 2005. The cetane number, rather than the cetane index, is selected to permit the use of cetane improvement additives. These recommended cetane numbers may force some refiners to address low-cetane cracked components in their diesel pool, but it will not force all producers to invest in technology to increase cetane values substantially. Because there is a limited number of test engines in Latin America that can calculate the cetane number of diesel fuel, it will be important that countries establish a relationship between the cetane number and cetane index of their diesel fuel for crude stocks and processing methods.

Proposed Sulfur Standard

3.46 Sulfur in diesel causes particulate emissions from vehicles, which has led many countries to propose that sulfur levels be decreased in diesel fuel. Specifications for sulfur currently vary from 500 to 10,000 wt ppm in diesel fuel sold in Latin America and the Caribbean. Most of the diesel that is produced in the region is much higher in sulfur than the 500 wt ppm specification in the United States and the 350 wt ppm specification proposed for the year 2000 in Europe.

3.47 It is proposed that the regional fuel specification be set at 5,000 wt ppm sulfur in the year 2001, and that this level be reduced to 2,000 wt ppm by the year 2005. The two-step process will reduce the fuel sulfur level to a marginally acceptable level by the year 2001, and it will offer an opportunity for a further reduction by the year 2005, which will require some investment, but not extreme hydrotreating.

Proposed Distillation Standard

3.48 The Latin American and Caribbean market is driven by diesel demand, and thus consideration should be given to the volume of diesel produced when setting specifications. Any decrease in T90 will increase the requirement for crude oil or the installation of cracking facilities. For this reason, it is proposed that the maximum T90 for diesel be set at 360°C.

3.49 It is recognized that a standard of 360°C is higher than the standards being proposed in many parts of the world, and that it may result in higher particulate emissions than would be experienced if the T90 temperature were reduced to a lower level. Individual countries may conclude that a T90 temperature of 320°C is justified in urban areas where PM_{10} emissions are a serious problem.

Proposed Aromatics Standard

3.50 Aromatic compounds in diesel can contribute to particulate emissions. Heavier aromatics also contribute to the emission of polynuclear aromatics. The reduction of aromatics in diesel fuel is an extremely expensive process, and substantial reductions in aromatics content are not reasonably achievable before 2005. At the same time, however, it would be inappropriate to provide diesel specifications that place no constraints on aromatics content.

3.51 It is proposed that diesel aromatics content be limited to 30 percent volume by the year 2005. This level should be achievable in the allotted time period.

Proposed Density Standard

3.52 Manufacturers of diesel engines design their engines for optimum operation over a range of fuel densities. Engine manufacturers advise that this density range is 820–860 kg/m^3, a range that this report proposes for adoption as a standard for diesel marketed in the Latin American and Caribbean region.

3.53 Limiting diesel density to a maximum density of 860 kg/m^3 will provide the benefit of reduced particulate emissions in regions where density currently exceeds that value.

LPG

Technical Issues

3.54 LPG markets in Latin America and the Caribbean are dominated by its use as a domestic fuel for both cooking and heating. In colder markets the fuel selected is usually propane, while in warmer markets the chosen product is a mixture of propane and butane. In a very limited part of the market, pure butane is used as a cooking fuel, and in some countries, propane is also used as an automotive fuel.

3.55 The technical issues relevant to cooking gas and other domestic and automotive uses are the consistency of composition of the fuels, the tendency of the fuels to emit noxious odors, and the content of heavier hydrocarbons in the fuels. There is also some concern that regions with colder ambient temperatures will have difficulty with fuel vaporization if the fuel has a high butane content.

Refinery Impacts

3.56 Changes in LPG specifications will generally have limited effects on refinery operation, although some refineries have limited capacity to separate LPG streams into pure components. In addition, the presence of high concentrations of olefins in LPG can compromise the quality and safety of the fuel, but some refiners have no alternative for propylene and butylene disposal.

Proposed Standard for Sulfur

3.57 The sulfur standard for LPG is generally set for control of noxious odors, not for the reduction of sulfur emissions. Since the combustion products from the fuel can enter living areas, it is important that sulfur levels be low.

3.58 It is proposed that the sulfur content of all LPG sold as an LPG mix or as a high-quality propane product be limited to a maximum of 140 wt ppm. This level should not normally require any special modifications in most refineries.

Proposed Standard for Composition

3.59 In setting standards for composition, there are two considerations that must be addressed—the consistency of composition and the content of heavier hydrocarbons. Consistency of composition is important because the fuel is often provided to the burner through a nozzle, which is sized for a particular fuel composition. Variable fuel composition can alter the combustion characteristics of the fuel and make combustion control difficult. The presence of heavier hydrocarbons alters the fuel's burning characteristics; in extreme cases, it can also allow liquid fuel to be fed to the burner.

3.60 It is proposed that the standard for butane-propane mixes be established at a level of 25–30 percent butane, a maximum of 2 percent C_{5+}. The C_{5+} standard is consistent with both the GPA (Gas Processors Association) standard and the ASTM standard, while the limit on butane content is consistent with the standards established by most of the Latin American and Caribbean countries that have standards for butane content in LPG mixes. Some climates with lower ambient temperatures may be unsuitable for a propane/butane mixture (30 percent butane), especially in the winter months. Once individual countries have established a specific butane-propane mix, it is suggested that they keep that mixture constant, so that manufactures of appliances can adjust the size of the opening to the butane to propane ratio.

3.61 It is also proposed that standards be established for a high-quality grade of propane that matches the ASTM D1835 and the GPA standard for HD-5 propane. The composition of this product would set a limit on butane and heavier hydrocarbons at a maximum of 2.5 percent. In countries where propane will be used as an automotive fuel, consideration should be given to setting a maximum propylene content of 5 vol%.

Light Fuel Oil

Technical Issues

3.62 For the purposes of this study, light fuel oil has been defined as distillate fuel oil that does not contain any residual hydrocarbons. This would correspond to U.S. #1 and #2 fuel oil as defined in ASTM D396-96. While this definition could be considered relatively restrictive, the issues surrounding the treatment of distillate fuel oil are quite different from those for heavier fuel oils, and the processes used to refine light fuel oils differ from those used to process heavy fuel oil.

3.63 The technical requirements for light fuel oil are not particularly restrictive, and the market for the product is relatively limited. While the specifications for fuel oil are less restrictive than for diesel, diesel is often used as light fuel oil, and the specifications proposed for diesel will also provide a suitable light fuel oil product.

3.64 For refiners who elect to make a unique fuel oil product, the most important specification for standards harmonization is the sulfur content. While low-temperature flow characteristics are important when light fuel oil is used in temperate climates, low-temperature flow characteristics are region-specific and should be part of the contracted quality of the fuel.

Refinery Impacts

3.65 The costs to refineries for changes in light fuel oil sulfur specifications will be small. The same process equipment used for sulfur reduction in diesel will generally be used for sulfur reduction in light fuel oil. The investment required for light fuel oil desulfurization will usually be limited.

Proposed Standard for Sulfur

3.66 It is proposed that the sulfur level for light fuel oil be limited to 5,000 wt ppm. While this level is higher than the standard set for diesel, it does address many of the concerns about light fuel oil without forcing the refiner to make an additional investment to meet standards for this product.

Other Considerations

3.67 There is a considerable market for both heavy fuel oil and the intermediate fuels that are made up of light fuel oil and residual material. While these fuels are not a part of this study, the emissions of sulfur oxides from their combustion are significant. It is recommended that consideration be given to establishing appropriate regional standards for heavy fuel oil.

4

Impact of Harmonization

Overall Refinery Impact

Current State of the Industry

4.1 The Latin American and Caribbean refining industry is generally characterized by low-complexity diesel and heavy-fuel-oil-producing facilities with few hydrocracking units, and limited upgrading capacities for reforming, alkylation, and hydrorefining. This lack of process flexibility creates a substantial barrier to rapid changes in product specifications.

Ability of Industry to Adapt to Specifications

4.2 The regional refining industry will generally have considerable difficulty meeting specification changes because most refiners have not invested in the technologies that are required to meet enhanced fuels specifications.

4.3 For the largest refineries (greater than 250,000 b/d), flexibility varies considerably from country to country. Mexico has made a considerable investment in its refining facilities and is quite advanced in its program to enhance fuels specifications. Venezuela, in contrast, has made little investment in providing high-quality fuels for its own domestic market, and its refineries will require significant investment to meet revised specifications. Other countries with large refineries have varying abilities to meet new standards, but most will require significant investment.

4.4 For the refineries in the 100,000–250,000 b/d range, there is broad variation in processing configurations and refinery complexities. Most refineries in this size range have some of the processes that are required to complete lead phase-out, but few have sufficient processing flexibility to meet all of the proposed standards. Refineries in the 50,000–100,000 b/d size range are usually less complex in their configuration and would have correspondingly greater investment requirements to meet the proposed standards.

4.5 Over half of the region's refineries have a capacity of less than 50,000 b/d, and most of these facilities lack significant processing flexibility. Many of these facilities will require investment far in excess of commercially justifiable amounts, and some may be shut down during the period of new standards implementation.

4.6 While the small refineries represent a substantial portion of the total number of facilities in the region, they represent only 8 percent of the crude processing capacity. The closure of these small facilities will thus not have a significant impact on the overall ability of the region to maintain self-sufficiency in refined-product supply.

4.7 Adoption of the enhanced specifications proposed in this report will force most refiners to make significant investments, but this would be true of any standards imposed on refineries with low complexity. The approach taken has been to develop logical standards that are affordable for most refiners in the region.

4.8 The simultaneous implementation of revised standards for both gasoline and diesel will force refiners to invest in a variety of process technologies at the same time. This approach will, however, give the refiners a clear picture of the direction of regulation and will allow them to make investment decisions that will provide a coherent development plan. This coherence will ensure that a reaction to a standard for one product will not increase the future problems for the production of another. It will also allow potential synergies in production options to be fully exploited.

4.9 It is recommended that the implementation of the standards proposed in this report take place in 2001 and 2005. The rationale for this two-stage approach is to achieve the steps that require little or no investment by 2001, the earliest date believed to be practical for regional changes in standards. For changes in specifications that require significant investment, 2005 was chosen as a target date because there is a requirement for considerable lead time for evaluation, design, and construction of new facilities.

Effect on Regional Trading

Existing Trade

4.10 Regional trade in fuels currently is limited because most countries have traditionally attempted to meet local demand with local supply. While a few of the larger crude-producing countries and a few of the large Caribbean refineries have had a significant export presence and have moved product to adjacent countries, the market has generally evolved as one of limited interchange, where each nation attempts to provide its own supply. This approach led to the operation of many small facilities that have been constrained for capital and are not well-positioned to meet future market requirements. This will force a number of countries to move from being crude importers to becoming product importers.

Future Trading Opportunities

4.11 Eliminating gasoline lead, and changing specifications such as octane and sulfur in diesel, will require significant investment in many refineries and may result in the shutting down of some of the smaller, marginal facilities. This will create additional trading opportunities for the remaining facilities that make the changes required to meet future product-quality standards.

4.12 The existing refining facilities are operating at about 77 percent of capacity. This is considerably less than the capacity utilization in most other parts of the world, and it suggests that there is adequate capacity in the short to medium term to meet consolidated regional demands. In addition, export opportunities will continue to expand as long as U.S. and European demand for products keeps growing and environmental regulations limit their ability to expand their internal industry.

4.13 Crude markets in Latin America and the Caribbean will not be affected significantly by the proposed changes in regulations. Intraregional trade in crude will increase slightly if regional refineries absorb more of the market. As sulfur limits in fuels are lowered, some refiners may elect to reduce their investment by processing lower-sulfur crude oils, but this trend is consistent with global trends, and changes in relative value of crudes will be more reflective of global trends than of regional changes. The crude price will not be affected by changes in specification because prices are generally driven by global factors, and this relatively minor change in the Latin America and the Caribbean will not be large enough to affect the global balance.

4.14 The direct financial benefits of harmonization will include economies of scale as facilities are added to meet future product quality requirements and the benefits of improved distribution economics. Capital investment in refining processes generally enjoys significant economies of scale, and as product quality forces refiners to develop more complex refining facilities, the larger facilities will be able to make that investment more cost-effectively than smaller facilities. Product from the larger facilities should be able to compete in cost with product from markets outside the region, and efficient markets should result.

4.15 The establishment of harmonized specifications will reduce the number of unique products that must be produced for the regional market and will allow the development of efficient distribution networks that will move similar product across national borders. Product differentiation will be required only where there are climatic factors that require differentiation or where regional needs (urban areas with special considerations, and the like) force differentiation.

4.16 The liberalization of the economies in many of the Latin American and Caribbean countries is also bringing multinational and larger regional companies into many parts of the region. These companies own facilities and trade refined products all over the world, and they have the capacity to put in place the necessary distribution systems so that economies can actually benefit from the economies of scale produced by regional harmonization.

5

Conclusions and Recommendations

5.1 The Latin American and Caribbean markets can be characterized as a series of unique national markets where limited effort has been made to achieve specifications harmonization. National specifications generally have been established to accommodate local refining capability; while standards have become more stringent in many countries, changes have tended to reflect domestic refining capability. If legislators move aggressively to enhance fuels standards without taking into account the state of the domestic refining industry, refiners may not be able to comply with regulations. Such a scenario would argue for the establishment of modest specifications enhancement, applied with sufficient lead time to allow for appropriate refinery investment.

5.2 Since there are many small refineries in the region, the implementation of enhanced standards can be most efficiently achieved through multicountry harmonization of specifications. This will allow smaller, less economic facilities to leave the marketplace, and facilities that are more capable of making investments to supply regional markets efficiently without supply disruptions to prosper. Harmonized specifications, if they are imposed with appropriate lead times, will allow optimization for the facilities that will be supplying the new regional market.

5.3 The basic specifications proposed in this report provide a framework for harmonized specifications throughout the region. While they do not address all issues that are important in the marketing of quality fuels, they do provide a baseline for the key parameters that influence fuels quality. The specific recommendations that are being made in this report are listed in Table 5.1–Table 5.4.

Table 5.1 Proposed Specifications for Unleaded Gasoline

Specification	*Regular*	*Premium*
RON, minimum	91	95
MON, minimum	82	85
RVP, psi, maximum	9.0 to 11.5	
T50, °C, maximum	120	
T90, °C, maximum	190	
Sulfur, wt ppm, year 2001, maximum	1,000	
Sulfur, wt ppm, year 2005, maximum	400	
Aromatics, vol%, maximum	45	
Olefins, vol%, maximum	25	
Benzene, vol%, maximum	2.5	
Oxygen, wt%, maximum	2.7	
Lead, g/l, maximum	0.013	

Note: Unless otherwise stated, the specifications should be applied by the year 2005.

Table 5.2 Proposed Specifications for Diesel

Specification	*Value*
Cetane number for year 2001, minimum	45
Cetane number for year 2005, minimum	47
T90, °C, maximum	360
Sulfur, wt ppm, year 2001, maximum	5,000
Sulfur, wt ppm, year 2005, maximum	2,000
Density, kg/m^3 at 15°C	820–860
Aromatics, vol%, maximum	30

Note: Unless otherwise stated, the specifications should be applied by the year 2005.

Table 5.3 Proposed Specifications for Liquefied Petroleum Gas, 2005

Specification	*Propane*	*Butane/propane mixture*
Sulfur, wt ppm, maximum	140	140
Mixture	–	25–30% butane
C_{5+}, vol%, maximum	–	2
Butane+, vol%, maximum	2.5	–

Table 5.4 Proposed Specifications for Light Fuel Oil for 2005

Specification	*Value*
Sulfur, wt ppm, maximum	5,000

5.4 It is recognized that these standards do not address all environmental concerns, especially those of some of more polluted urban areas. Enhanced fuels standards may be required for urban centers where there are special environmental considerations. The challenges that the Latin American and Caribbean community faces as it moves toward enhanced fuels standards will be significant, but with a reasonable harmonization framework, fuels quality improvement will be achievable with a minimum amount of investment and hardship.

Bibliography

Alconsult International, Ltd. (1996), *Study Concerning the Elimination of Lead in Gasoline in Latin America and the Caribbean.* Calgary, Alberta, Canada.

Alconsult International, Ltd. (1996), *Database for the Study Concerning the Elimination of Lead in Gasoline in Latin America and the Caribbean.* Calgary, Alberta, Canada.

American Society for Testing and Materials (1997), "Standard Specifications for Automotive Spark-Ignition Engine Fuel," Designation: D4814-96. In *1997 Annual Book of ASTM Standards*, Section 5, Vol. 05.03. West Conshohocken, Pennsylvania.

American Society for Testing and Materials (1997), "Standard Specifications for Fuel Oils," Designation: D396-96. In *1997 Annual Book of ASTM Standards*, Section 5, Vol. 05.01. West Conshohocken, Pennsylvania.

American Society for Testing and Materials (1997), "Standard Specifications for Diesel Fuel Oils," Designation: D975-96a. In *1997 Annual Book of ASTM Standards*, Section 5, Vol. 05.01. West Conshohocken, Pennsylvania.

American Society for Testing and Materials (1997), "Standard Specifications for Liquefied Petroleum (LP) Gases," Designation: D1835-91. In *1997 Annual Book of ASTM Standards*, Section 5, Vol. 05.01. West Conshohocken, Pennsylvania.

Auto/Oil Air Quality Improvement Research Program (1997), *Program Final Report.*

Beicip Franlab Petroleum Consultants (1997), *Etude pour la Promotion de l'essence sans Plomb en Amerique Latine—Cas du Paraguay.* OLADE, Commision Europeene.

Beicip Franlab Petroleum Consultants (1997), *Etude pour la Promotion de l'essence sans Plomb en Amerique Latine—Cas de L'Equateur.* OLADE, Commision Europeene.

Beicip Franlab Petroleum Consultants (1997), *Etude pour la Promotion de l'essence sans Plomb en Amerique Latine—Cas du Panama,* OLADE, Commision Europeene.

British Petroleum Statistical Review of World Energy, 1997. London

Canadian Petroleum Products Institute (1992), *Discussion Paper on the Role of Gasoline Formulation in the Reduction of Transportation Emissions in Canada.* Ottawa, Canada.

Sheila Chernys (1996), *Impact of Highly Reformulated Gasolines on Light Duty Vehicle Emissions*. Environment Canada, Mobile Sources Emissions Division, Report # 95-26761.

Comite Ambiental Secretaria General ARPEL (1997), *Influence of Vehicle Fuels on Atmospheric Emissions*.

Cunningham, Robert E., Michalski, George W., Miller, Charles L., Anderson, David R., Auers, John R., and Adams, Robert M. (1992), *Costs of Alternate Gasoline Reformulation—Results of U.S. Refining Study for Economics Committee of the Auto/Oil Air Quality Improvement Research Program*. Turner, Mason & Company.

Darlington, T., and Rykowski, R. A., *Exhaust Particulate Emissions from Gasoline-Fueled Vehicles*. General Motors Corporation, U.S.A.

Kenneth T. Derr (1993), *U.S. Petroleum Refining—Meeting Requirements for Cleaner Fuels and Refineries*. Washington, D.C., National Petroleum Council.

European Programme on Emissions, Fuels and Engine Technologies, ACEA and Europia.

Faiz, Asif, Weaver, Christopher S. and Walsh, Michael P. (1996), *Air Pollution from Motor Vehicles*. Washington, D.C., World Bank.

Neil A. Franklin (1997), *Impact of Fuel Switching on Refinery Operations and Atmospheric Emissions* (Draft). ARPEL Comite Ambiental, Secretatia General, April 7, 1997.

B. M. Harney (1992), *Economic Bulletin No. 2. Estimated Costs of Modifying Gasoline Properties.* Air Quality Improvement Research Program.

Michelle Heath (1991), *Alternative Transportation Fuels: Natural Gas, Propane, Methanol and Ethanol Compared with Gasoline and Diesel.* Canadian Energy Research Institute, Calgary, Alberta.

Hydrocarbon Processing (1996), "How to Implement a Gasoline Pool Lead Phase-Down" (February): 63.

Hydrocarbon Processing (1996), "Europe's Refiners Reduce Sulfur Emissions: New Regulations Vary" (July): 29.

Hydrocarbon Processing (1996), "Latin America's Oil Product Demand to Grow 2.3%/Year Through 2000" (September): 25.

Hydrocarbon Processing (1996), "The Chemical Industry by Country" (September): 118S.

Hydrocarbon Processing (1997), "European Union Sets Cleaner Fuel Specs" (January): 27.

Hydrocarbon Processing (1997), "Making 'Premium' Diesel Fuel" (February): 63.

Hydrocarbon Processing (1997), "Refiner Options for Converting and Utilizing Heavy Fuel Oil" (February): 75.

Hydrocarbon Processing (1997), "Trends in Catalysis Research to Meet Future Refining Needs" (February): 45.

International Energy Statistics Sourcebook (1995), Fifth Edition. Tulsa, Oklahoma, Pennwell Publishing.

International Petroleum Encyclopaedia (1996), Tulsa, Oklahoma, Pennwell Publishing.

Koehl, W. J., Benson, J. D., Burns, V. R., Gorse, R. A., Jr., Hochhauser, A. M., and Reuter, R. M. (1992), *Effects of Gasoline Composition and Properties on Vehicle Emissions: A Review of Prior Studies—Auto/Oil Air Quality Improvement Research Program*, SEA 91231.

Magda Lovei (1996), *Phasing Out Lead from Gasoline: World-Wide Experience and Policy Implications*, Environment Department Paper No. 040, Washington, D.C., World Bank.

Oil & Gas Journal (1993), "Rising Costs Call for New European Refining Strategies." (July 19):30.

Oil & Gas Journal (1993), "NPC: U.S. Refiners Can Meet Environmental Regulations, but..." (September 13): 30.

Oil & Gas Journal (1996), "Global Refining Industry Preparing for Future" (April 10): 47.

Oil & Gas Journal (1996), "Complexity Index Indicates Refinery Capability, Value" (March 18): 74.

Oil & Gas Journal (1996), "Venezuelan Refiner Completes $2.5 Billion Refinery Expansion" (March 18): 51.

Oil & Gas Journal (1996), "U.S. Refiners Face More Challenges in Wake of RFG Introduction" (April 22): 23.

Oil & Gas Journal (1996), "Low Sulfur Diesel Controversy Continues" (April 22): 75.

Oil & Gas Journal (1996), "European Refiners Must Seek Creative Processes to Justify Heavy-Ends Projects" (Special Edition, December 9): 53.

Oil & Gas Journal (1997), "Major Overcapacity Woes Loom for Oxygenates Despite Rising Demand" (March 31): 21.

Oil & Gas Journal (1997), "Vehicle Fleet Growth to Sustain Oil Demand" (March 31): 28.

Secretaria General de ARPEL (1995), *Datos Estadisticos de la Industria Petrolera y Gasifera de la Region Latinoamericana*. Montevideo, Uruguay.

Secretaria General de ARPEL (1997), *Banco de Datos de ARPEL, Archivo de Empresas—Empresas Refinadoras en la Region* . Montevideo, Uruguay.

Secretaria General de ARPEL (1997), *Boletín Técnico*. Montevideo, Uruguay.

Secretaria General de ARPEL (1997), *Calidad de Productos Combustibles en America Latina y el Caribe— Analisis comparativo de las especificaciones utilizadas en la region*. Montevideo, Uruguay.

Toyota Canada, Inc. (1997), "Toyota's Comments on Fuel Usage and Quality in Latin America and Caribbean Markets" (Response to questionnaire sent to vehicle marketing department).

U.S. Department of Energy (1996), *Promotion of Capital Investment in the Petroleum Refining Sector of the Americas*. Washington, D.C.

Jane Wiltshire (1996), *Challenges for Oil Refining— Meeting New Fuel Specifications and Emissions Legislation*. London, Financial Times Energy Publishing.

World Bank (1997), *Elimination of Lead in Gasoline in Latin America and the Caribbean: Status Report, December 1996*. ESMAP Report No. 194/97EN. Washington, D.C.

Annex: Summary of Current Specifications

Table A.1 Gasoline (unleaded)

Country	*RON*	*RVP, psi*	*T50 °C*	*T90 °C*	*Sulfur, wt ppm*	*Benzene, vol%*	*Oxygenates, vol%*
Argentina	83					4.0	15.0
Barbados	95	5.5–10.5	88–121	177	1,000		15.0
Bolivia	80	10.0	116	193	500		
Brazil		10.0	140	200	2,000	1.0	21–23
Chile	93	10.0	121	190	1,000	2.5	12.0
Colombia	86	9.0	112	190	1,000	1.1	
Costa Rica	91	8.4	101	163	500		
Dom. Rep.	92	9.5	115	180	1,500		
Ecuador	80	8.1	121	190	2,000	2.0	
El Salvador	87	10.0	121	190	1,500		
Guadeloupe	95	10.0	140	210	1,000	5.0	
Guatemala							
Honduras	87	10.0	121	190	1,500		
Jamaica	93	9.0	121	190	1,000	5.0	10.0
Martinique	95	10.0	140	210	1,000	5.0	
Mexico	82	9.6	118	190	1,000	2.0–4.9	10.0
Nicaragua	87	10.0	140	190	1,000		
Panama		10.0	125	180	1,000		
Paraguay	93	11.0	118	190	2,000		
Peru	90	12.0	140	200	2,000		15.0
Suriname							
Trinidad	90	9.0		180	1,500		
Uruguay	95	10–12	140	200	2,000	2.2	15.0
Venezuela							

Table A.2 Diesel

Country	*Cetane (I) index, (N) number*	*Sulfur, wt ppm*	*T90, °C*
Argentina	48 (I)	2,500	360
Barbados	42 (I)	5,000	365
Bolivia	45 (I)	3,000	382
Brazil	45 (I)	3,000–10,000	360
Chile	45 (N)	3,000–5,000	357
Colombia	45 (I)	4,000	360
Costa Rica	45 (I)	500	338
Ecuador	45 (I)	8,000	365
El Salvador	45 (I)	5,000	363
Guadeloupe	47 (I)	8,000	357
Guatemala	45 (I)	5,000	337
Honduras	45 (I)	5,000	343
Jamaica	45 (N)	5,000	352
Martinique	47 (I)	8,000	360 (T85)
Mexico	45–48 (I)	500	345–350
Nicaragua	40 (I)	6,000	282–338
Panama	48 (I)	5,000	282–338
Paraguay	45 (I)	5,000	360–370
Peru	45 (N)	3,000–10,000	288–357
Suriname	46 (I)	5,000	343
Trinidad	45 (I)	5,000	357
Uruguay	48 (I)	8,000	360
Venezuela	43 (N)	10,000	360

Table A.3 LPG and Light Fuel Oil

Country	*LPG sulfur, wt ppm*	*Light fuel oil sulfur, wt%*
Argentina		1.4
Barbados		
Bolivia	150	1.0
Brazil	157	1.0–5.0
Chile	150	4.0–5.0
Colombia	150	1.5
Costa Rica	170	
Ecuador	150	1.7
El Salvador	150	3.0
Guadeloupe	135	4.0
Guatemala		3.5
Honduras		
Jamaica		3.0
Martinique	135	3.0–4.0
Mexico	140	0.5–2.0
Nicaragua	140–185	3.0
Panama	140	3.5–4.0
Paraguay	140	0.2–0.9
Peru	100–150	1.5–3.5
Suriname	123	0.65
Trinidad	123–180	
Uruguay	148	0.65–3.0
Venezuela	140–185	1.0–3.5

Joint UNDP/World Bank

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95

Region/Country	*Activity/Report Title*	*Date*	*Number*
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87

Region/Country	*Activity/Report Title*	*Date*	*Number*
Mauritius	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	--
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
South Africa Republic of	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90

Region/Country	*Activity/Report Title*	*Date*	*Number*
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--

EAST ASIA AND PACIFIC (EAP)

Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86

Region/Country	*Activity/Report Title*	*Date*	*Number*
Indonesia	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--

Region/Country	*Activity/Report Title*	*Date*	*Number*
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector	06/98	205/98
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
Eastern Europe	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazahstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazahstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Turkey	Energy Assessment (English)	03/83	3877-TU

MIDDLE EAST AND NORTH AFRICA (MNA)

Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
Morocco	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
	Energy Sector Institutional Development Study (English and French)	07/95	173/95
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90

Region/Country	Activity/Report Title	Date	Number
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN (LAC)

Region/Country	Activity/Report Title	Date	Number
LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--

Region/Country	*Activity/Report Title*	*Date*	*Number*
Ecuador	Private Minihydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93

Region/Country	*Activity/Report Title*	*Date*	*Number*
	GLOBAL (Continuation)		
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98

07/01/98