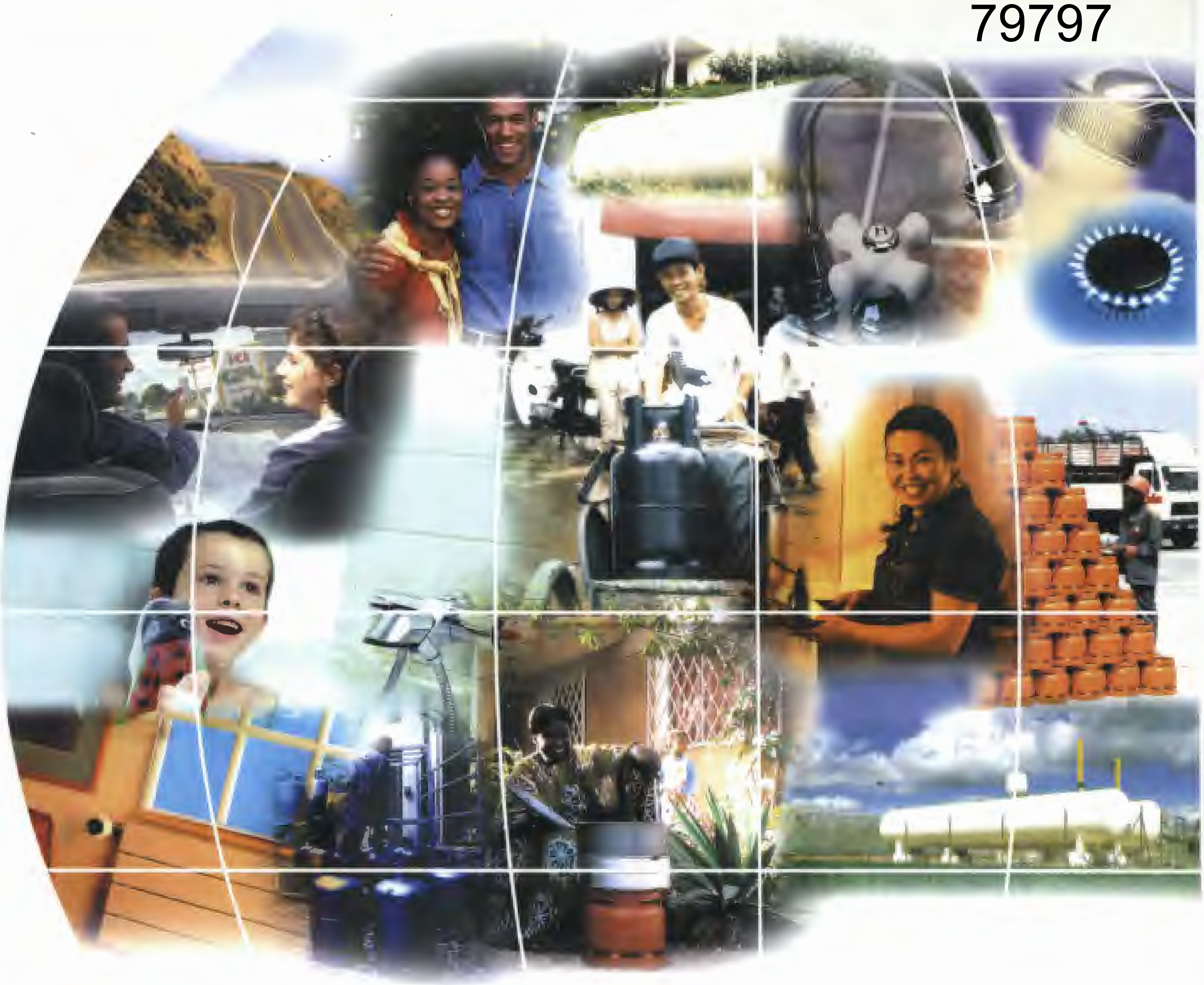

The Role of LP Gas in Meeting the Goals of Sustainable Development

WORLD LP GAS ASSOCIATION

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT
WORLD BANK

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WORLD LP GAS ASSOCIATION *THE WORLD BANK*

FOREWORD

Energy is an essential component of sustainable economic and social development. An estimated two billion people in the world do not yet have access to modern fuels. It is widely recognised that the transition from traditional fuels, such as wood, charcoal and dung, to modern commercial fuels can bring significant social and economic benefits. Modern fuels must, therefore, form a central element in moving developing countries onto more sustainable development paths.

LP Gas can make a major contribution to achieving this goal. Of all the modern fuels available today, LP Gas is particularly well suited to domestic cooking and heating uses because of its clean-burning attributes and practical advantages.

The environment - together with economic and social development - forms the other main pillar of sustainable development. LP Gas can bring real environmental and health benefits at the local, regional and global levels in both industrialised and developing countries, through lower emissions of air-borne pollutants and climate-destabilising greenhouse gases compared to other fossil fuels and traditional fuels used in unsustainable ways. By reducing demand for wood and charcoal, it can also limit deforestation pressures in developing countries.

This study, co-sponsored by the World Bank and the World LP Gas Association, assesses the role of LP Gas in meeting sustainable development objectives. It is the first major study that focusses on this subject. It is intended to help policymakers and LP Gas industry stakeholders understand better the contribution that LP Gas is making in moving the world onto a more sustainable development path and the issues that will need to be addressed to ensure that LP Gas' potential is fully realised. By encouraging access to clean, commercial fuels, it is hoped that the study will help fight poverty in developing countries.

This study builds on recent work carried out by both organisations on LP Gas market development, including a joint World Bank/WLPGA study of the West African LP Gas market. It also provides a bridge to detailed analysis of the energy implications of sustainable development by other international organisations, such as the International Energy Agency and the United Nations Environment Programme, who actively contributed to this study.

EXECUTIVE SUMMARY

ENERGY AND SUSTAINABLE DEVELOPMENT

Energy is implicated deeply in all three pillars of sustainable development - the economy, social welfare and the environment. Although there are no near-term resource limits to energy supply, today's global energy system is not compatible with economic, social and environmental sustainability in the long-term. A lack of access to reliable and affordable energy undermines economic development in many parts of the world. The detrimental environmental consequences of energy production and use around the world threaten the stability of eco-systems and the health and well being of current and future generations. In addition to creating local and regional pollution, rising fossil fuel use in all regions carries the long-term risk of disrupting climate as a result of emissions of greenhouse gases that trap heat in the earth's atmosphere.

Moreover, modern fuels are not universally available. An estimated two billion people in the world do not yet have access to modern fuels. Around one-quarter of all energy consumed in developing countries is derived from the burning of wood, charcoal, crop residues and animal dung. In the poorest countries, households rely almost exclusively on such traditional fuels. People - most often women and children - can spend a long time gathering these fuels, reducing the time they can devote to productive agricultural activities and education and holding back economic and social development. This inequity has important moral and political implications. Finding ways to expand energy services to poor households in developing countries, while simultaneously addressing the environmental effects of energy production and use, is one of the most pressing challenges facing the world today.

The transition to modern fuels is both a consequence of and a necessary condition for more sustainable development.

The transition to modern fuels is both a consequence of and a necessary condition for more sustainable development. The process normally begins with households, farmers and small enterprises switching from traditional fuels to intermediate modern fuels such as kerosene and coal. As incomes rise further, the use of advanced modern fuels such as liquefied petroleum gas (LP Gas), natural gas (where available in urban areas) and electricity expands. Where natural gas becomes widely available as the economy matures, LP Gas may itself be displaced to some extent by natural gas. Concerns over the environmental impact of energy use may also promote a shift towards renewable energy technologies, although they remain in most cases considerably more expensive than fossil fuel based technologies. Widening access to modern fuels in the poorest developing countries is limited by extreme poverty, which keeps these countries in a vicious circle of under-development. Policies to improve energy access, therefore, need to go hand-in-hand with broader economic policies to promote investment, growth and productive employment - especially in rural areas.

THE CONTRIBUTION OF LP GAS TO SUSTAINABLE ENERGY DEVELOPMENT

LP Gas is already playing an important role in steering both industrialised and developing countries onto more sustainable energy development paths. It contributes to strengthening the three pillars of sustainable development: the economy, by boosting productivity; social welfare, by improving living standards and enhancing safety; and the environment, by reducing indoor and outdoor pollution.

Of all the modern fuels available today, LP Gas, which consists mostly of propane and butane, is particularly well suited to domestic cooking and heating uses because of its clean-burning attributes and practical advantages over traditional fuels and kerosene. In particular, it is more convenient, safer and cleaner. It is also highly portable and has a high calorific value by volume and mass. Households recognise these advantages and are usually prepared to pay a premium for LP Gas over other fuels, if their incomes are high enough.

Switching to LP Gas is bringing considerable health and environmental benefits at the local, regional and global levels.

Switching from traditional fuels, coal and kerosene to LP Gas is bringing considerable health and environmental benefits at the local, regional and global levels. Indoor pollution, which mainly affects women and children, is greatly reduced. Urban air pollution and emissions of climate-destabilising greenhouse gases from LP Gas, calculated on a fuel-cycle basis, are lower than from most other fossil fuels and traditional fuels used in an unsustainable way. By reducing demand for wood and charcoal, switching to LP Gas can also reduce deforestation and can free up supplies of dung for use as a fertiliser and a soil enhancer, enhancing agricultural productivity. LP Gas is also safer than most other fuels, especially kerosene. Switching from conventional transport fuels to LP Gas (autogas) can also make a major contribution to reducing airborne emissions in both developing and developed countries.

LP Gas is a finite resource and, as a fossil fuel, is not environmentally benign. It cannot, therefore, be considered a sustainable energy source in the very long term. But LP Gas can play an important role in the overall transition to a truly sustainable global energy system. LP Gas' comparative advantages over most other fuels mean that it can make energy development more sustainable until such time as affordable and environmentally acceptable renewable energy technologies become available. This may take several decades: fossil fuels are expected to meet most of the increase in energy demand for at least the next two to three decades.

Household demand in developing countries has accounted for most of the growth in world LP Gas use over the last ten years. The growth in household use of LP Gas has been spectacular in some developing countries. Residential LP Gas demand in China, for example, grew by 26% per year from 1990 to 1999. The use of LP Gas in households remains significant in many industrialised countries, mainly where it is not economic to extend natural gas distribution networks.

Rising Supply of LP Gas

The role of LP Gas in meeting sustainable development goals should continue to grow in the future. There is considerable potential for expanding LP Gas supply to residential markets in developing countries. Global output is expected to rise steadily in the next few years, thanks to increased processing of natural gas and rising oil-refinery throughputs. The growth in production of LP Gas will probably outstrip that of most other oil products, since natural gas processing - now the largest source of LP Gas - is increasing more rapidly than crude oil processing. Rising natural gas production will add to the amount of gas that is processed and boost the supply of propane and butane. Reduced flaring of natural gas in many countries as markets develop will also boost LP Gas supply: Saudi Arabia and Nigeria, which flare gas the most, both plan to phase out the practice.

Some of the expected increase in supply is earmarked for petrochemical projects that are already under construction or planned. The residential sector in developing countries could absorb a large proportion of the rest.

Factors Driving LP Gas Market Growth in Developing Countries

Economic and population growth will most likely continue to drive rapid growth in LP Gas markets in developing countries for at least the next decade or two, particularly in households and small commercial activities in urban and peri-urban areas. But the rate of growth in different countries and regions will depend on a number of factors influencing both the availability of and demand for LP Gas.

Expanding the supply of LP Gas will require significant investments in distribution and marketing infrastructure, particularly in rural areas where LP Gas is not yet available. The scale of investment is, nonetheless, much less than that required for natural gas distribution. Market conditions and regulatory frameworks will determine the attractiveness of LP Gas markets to private investors. The public policy and regulatory framework is a key determinant of investment risk and, therefore, the required return on that investment. Key aspects of the regulatory regime include:

- The stability of the political and legal system and the regulatory regime.
- Rules governing trade and investment, such as licensing of distribution and repatriation of profits, and the rate of taxation of corporate profits.
- Controls over wholesale and retail prices and margins.
- Regulations concerning industry operating and safety standards, and how rigorously they are enforced.

Where LP Gas is available to households, its affordability and competitiveness are the main factors driving residential demand. The key determinants of affordability are household incomes and the price of the fuel. When significant numbers of households are able to afford LP Gas, demand depends on how competitive it is against alternative fuels such as kerosene, charcoal or, if heavily subsidised, electricity. If those fuels are much cheaper than LP Gas, households may prefer them. Where natural gas distribution infrastructure is in place, LP Gas is unlikely to be competitive in most cases.

A key factor affecting affordability for poor households is the initial cost of the gas cylinder (either the deposit or the outright purchase cost) and the stove, which tends to be more expensive than for other fuels. Overall, the initial investment cost for LP Gas is significantly higher than for kerosene, coal or charcoal. This discourages switching to LP Gas in poor countries, where poor people may have neither adequate cash reserves nor access to credit.

The Impact of Government Policies on LP Gas Use

Active government support can establish a virtuous circle of growing market potential, increased investment and expanded availability.

Government policies and measures can strongly influence LP Gas market development. There is a good case for government support to the LP Gas sector in developing countries in view of the positive contribution the fuel can make to more sustainable energy use. Active government support can catalyse LP Gas market take-off and establish a virtuous circle of growing market potential, increased investment and expanded availability.

Government support can take various forms. These include measures to make the general regulatory and business environment more favourable to investment in bulk transportation and distribution infrastructure, and measures to make LP Gas more affordable and competitive. Governments can also help poor households gain access to credit.

In many developing countries, private investment in the LP Gas industry is impeded by the dominance of state-owned enterprises, which often benefit from monopoly rights. The performance of these companies and their ability to invest are often dismal. Privatisation and the introduction of an effective regulatory regime can boost private investment. Liberalisation of LP Gas importing, wholesaling and retailing, involving the removal of exclusive rights and controls over prices or distribution margins, can provide a major stimulus to the market. In much of Asia and Latin America, the opening up of the LP Gas sector to private participation and competing suppliers has had a tremendous impact on expanding supply to the household sector over the last decade.

Where conditions are not conducive to attracting private investment, public-private partnerships may offer an alternative source of funding. This approach may also be more politically acceptable in some countries. Private investors, however, need to be reassured that political objectives and public-service obligations will not undermine investment returns.

LP Gas Subsidy Programmes

Direct subsidises to the fuel itself and to the appliances and equipment needed to use the fuel are the most common form of direct support to LP Gas. Most developing countries subsidise LP Gas, often along side other modern fuels, although many are now attempting to remove or reduce fuel subsidies. The most common type of subsidy is price controls that keep the retail prices of the fuel or related equipment below their true market cost. Their long-term impact on consumption depends crucially on how subsidy programmes are designed, whether other fuels are subsidised and the broader regulatory framework in which they are implemented.

LP Gas subsidies have been effective in several countries in speeding up the transition from traditional fuels and bringing significant social, environmental and economic benefits to millions of households. The major shift to LP Gas and kerosene since the 1980s in India, for example, has been brought about by large subsidies. This transition has produced substantial improvements in indoor and urban air quality and has reduced deforestation in rural areas close to major urban centres.

But subsidy programmes may involve significant costs too. Depending on their size and how they are structured, they may reduce incentives to invest, discourage efficiency, encourage wasteful consumption, burden government finances and cause physical shortages. Moreover, the benefits of subsidies may not reach the poor for whom they are intended.

A good subsidy is one that enhances access to modern energy for the poor for a limited period while sustaining incentives for efficient distribution and consumption and reducing adverse environmental effects.

Energy subsidies have received a bad press in recent years because of these problems. But not all energy subsidies are bad. A good subsidy is one that enhances access to modern energy for the poor for a limited period while sustaining incentives for efficient distribution and consumption and reducing adverse environmental effects. In practice, therefore, the net benefit of subsidies in bringing about a non-reversible transition to modern fuels taking account of the costs must be assessed on a case-by-case basis. Key factors that influence their cost-effectiveness are how well the subsidy is targeted, the mechanism for reducing prices to consumers, whether the fuel itself or the equipment is subsidised and the size of the subsidy. Subsidising the acquisition of the LP Gas cylinder and stove makes sense where these costs represent a major barrier to switching for poor households. Where that subsidy is not sufficient to encourage a large shift in household energy use to LP Gas, an appropriately sized, temporary subsidy on the fuel itself to small users may be justified.

Recommendations to Policymakers

Policies to promote LP Gas use should form part of a broader policy of expanding the use of modern fuels in developing countries. Such policies should be compatible with each country's overall strategy for sustainable development and poverty alleviation. The best approach will depend on national and local circumstances. These include national policy objectives and priorities, the country's stage of economic development, market and economic conditions, the state of public finances and the institutional framework.

The conditions for developing a successful LP Gas industry are not much different to those for any other fuel. Experience has shown that the following principles can provide a practical basis for effective policies aimed at expanding modern energy services in the household sector:

- *The provision of energy services should be competitive:* Competition allows consumers to choose between fuels and between suppliers. It promotes service quality and drives down costs.
- *The market should set prices:* All controls over pricing should be removed once competition is established. For as long as the state retains control over pricing, it should adopt import-parity (or international market-related) pricing.
- *Taxes should not undermine consumption nor distort the market inadvertently:* Any differentials in tax rates between different household fuels should be justified by legitimate social or environmental arguments. Given the benefits of LP Gas over traditional fuels and kerosene, taxes on LP Gas should be kept to a minimum so as not to harm its competitiveness and discourage its use.
- *Subsidies should be targeted, transparent, practical and temporary:* Where justified and feasible, subsidies should be aimed at rural households and the urban poor who would otherwise not use modern fuels. Subsidy programmes should not be unduly costly, taking account of the resources required to administer them and to monitor, prevent and deal with abuse. The financial costs and the channels through which cash payments are made must be fully transparent. On-budget costs should be properly accounted for and the results made available to the public. Subsidies should normally be regarded as a temporary measure to support switching from traditional fuels and should not be kept in place indefinitely.
- *Barriers to market entry should be removed:* Laws and regulations that impede trade and investment, including restrictions on repatriation of profits, should be removed. State-owned enterprises should compete on an equal footing with private companies. Privatisation or private-public partnerships should be considered as a way of attracting private capital.

- *Barriers to switching to modern fuels should be addressed:* Emphasis should be given to subsidising the initial cost of service, where this is a barrier to fuel switching. Subsidies can be used to lower the cost of the cylinder and stove for the poorest households. Support should also be given to micro-credit organisations that help these consumers overcome these barriers. At a minimum, financing and banking laws should not erect unnecessary barriers to the development of micro-credit financing arrangements targeted at the poor.

- *Awareness about comparative fuel costs and attributes should be promoted:* Governments should disseminate information and raise awareness among households about the costs and practical benefits of modern fuels compared with traditional fuels.

In promoting LP Gas use, governments must give over-riding attention to safety aspects. Poor safety practices undermine consumer confidence and market development. Governments should establish clear regulatory frameworks for the safe handling of LP Gas throughout the supply chain. It is essential that the public authorities, in partnership with the LP Gas industry, lay down and enforce appropriate harmonised operating standards for LP Gas distribution and cylinder handling.

Policies and measures to promote autogas use, both in developed and developing countries, need to take account of the barriers to switching. Experience has clearly shown that the single most important measure to making autogas an attractive fuel to vehicle owners is to ensure that pump prices are competitive with conventional fuels through lower taxes or tax exemptions. This approach usually needs to be backed up by complementary policy initiatives, including other fiscal and financial measures and non-financial regulatory initiatives. Whatever the approach adopted, a strong long-term policy commitment is crucial to give end users, fuel providers and vehicle manufacturers confidence that the development of the autogas market is sustainable. End users need to be sure that the savings in running costs will ultimately pay back their initial investment in converting their vehicles. This in turn will encourage vehicle manufacturers to develop and market higher performance dedicated vehicles and fuel providers to make the necessary investments in the distribution infrastructure.

Putting these principles into practice should involve a partnership between government and other stakeholders, including the LP Gas industry, local communities and consumer representatives. Governments may also need to work with regional bodies to exploit potential economies of scale in importing and distributing LP Gas.

CONTENTS

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The project was conceived and co-ordinated jointly by Mr. Mourad Belguedj, Lead Energy Specialist at the World Bank, and Mr. Emmanuel Chantelot, Managing Director of the World LP Gas Association.

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1 INTRODUCTION

1.1 OBJECTIVES AND SCOPE OF THE STUDY

The primary objective of this study is to identify and assess the main economic and policy factors that are driving the role of LP Gas in the energy mix globally, and in developing countries specifically in the context of sustainable development. It is intended to help policymakers and LP Gas industry stakeholders understand better the contribution that LP Gas is making in moving the world onto a more sustainable development path and the issues that will need to be addressed to ensure that LP Gas' potential is fully realised.

In particular, the study seeks to address the following questions:

- How big a role could LP Gas play in expanding the availability of modern energy services to poor people in developing countries and thereby contribute to meeting sustainable development objectives?
- What is the current role of LP Gas in the global energy mix and what are the structural characteristics of the LP Gas industry at each level of the supply chain?
- What are the principal drivers of LP Gas supply at the upstream and downstream levels and LP Gas demand in the main consuming regions and sectors?
- What are the main economic, technical and policy hurdles to establishing and promoting the growth of LP Gas markets and distribution infrastructure in developing countries? How might these barriers be overcome?

The geographic scope of the study is global, but emphasis is given to the economic and policy factors driving demand and the development of the supply and distribution infrastructure in developing countries. This reflects the expectation that much of the growth in LP Gas demand over the coming years will be in those regions.

The demand analysis covers the four main sectoral markets - petrochemicals, industry, transport and the residential/commercial sector - in broad terms. It focuses on the residential sector, which is expected to be the main source of market growth in developing countries in the coming years. The role of LP Gas as a transport fuel (autogas) in making transport energy use more sustainable is also addressed.

The analysis and conclusions draw heavily on detailed case studies of LP Gas market development in three developing regions and countries: the West African region, Brazil and India. These case studies illustrate the main issues associated with the availability, accessibility, affordability and acceptability of LP Gas (including problems encountered in promoting switching from traditional fuels), the successes of government programmes and the lessons learned.

1.2 ORGANISATION OF THE STUDY

Menecon Consulting was retained to compile information on LP Gas markets, analyse the issues related to the fuel's contribution to meeting sustainable development objectives and draft this report. The research and analysis benefited from interviews with officials from international organisations, energy companies and developing countries.

The project co-sponsors, the World Bank and the World LP Gas Association, with Menecon Consulting's assistance, established a panel of peer reviewers, including senior sector specialists from the International Energy Agency and the United Nations Environment Programme, to oversee the findings of the study. The World Bank compiled comments from several in-house experts, while the World LP Gas Association co-ordinated comments from a number of member companies.

1.3 STRUCTURE OF THE REPORT

Section 2 of this report outlines in broad terms the energy dimension of sustainable development, including the role of energy in the environmental, social and economic components of sustainability. It also assesses differences in policy objectives among regions according to their stage of development and the implications of sustainable development for energy policy. Section 3 discusses the transition to modern fuels in the context of economic development. Section 4 focuses on the characteristics of LP Gas and its supply chain, and its advantages over traditional fuels and other modern fuels. Section 5 describes historical trends in supply and consumption and the medium-term prospects for regional markets.

The rest of the report considers the economic and policy factors driving the supply and use of LP Gas in developing countries. Section 6 assesses qualitatively the factors driving residential LP Gas use and the principal barriers to market growth. Section 7 focuses on government policies to promote residential LP Gas use, including the regulatory framework, subsidy schemes and micro-credit financing. Section 8 sets out three case studies of LP Gas market development. The final Section summarises the conclusions and recommendations for policymakers.

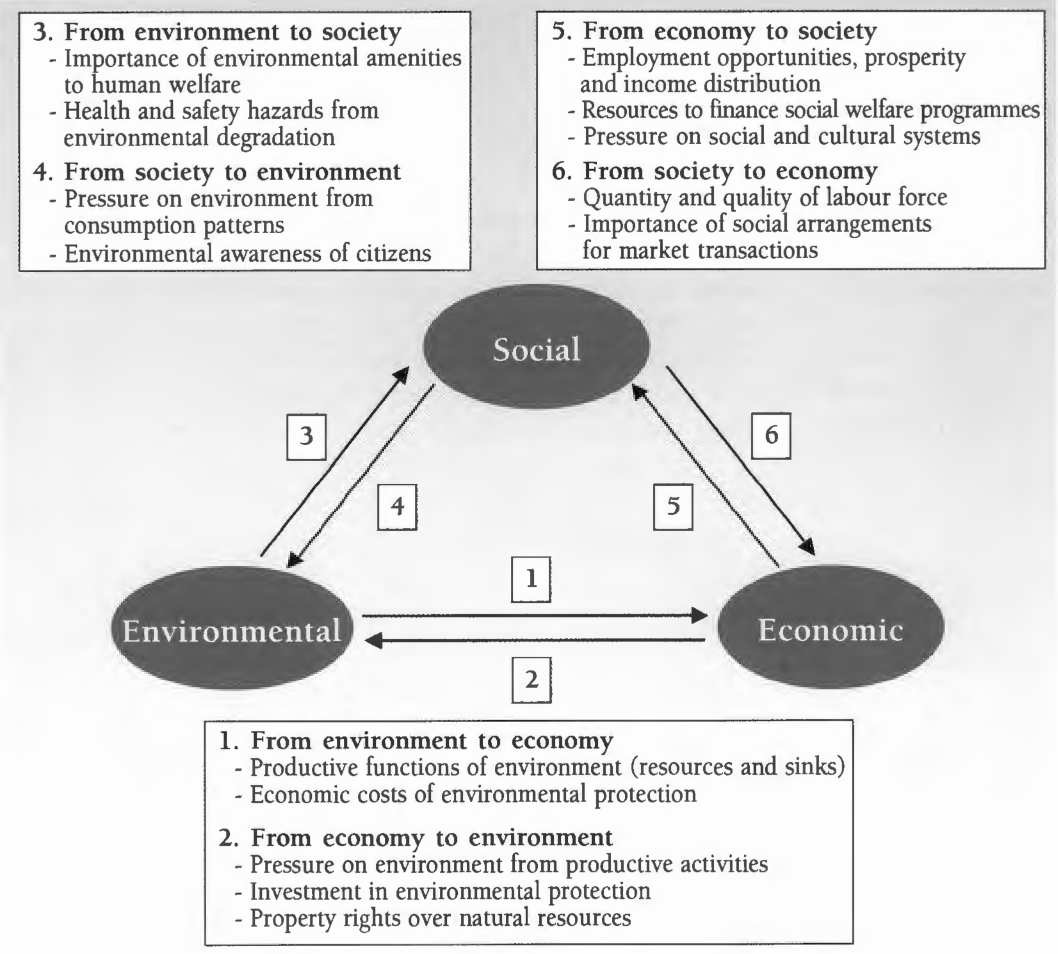
2 THE ENERGY DIMENSION OF SUSTAINABLE DEVELOPMENT

2.1 DEFINING SUSTAINABLE DEVELOPMENT

The fundamental goal of sustainable development is the quality of economic growth as well as its quantity.

In its broadest sense, sustainable development concerns the long-term compatibility of the economic, social and environmental dimensions of human well being. The 1987 Brundtland Report, which set in motion the process of incorporating sustainability into economic policy-making, defined sustainable development *as development that meets the needs of the present without compromising the ability of future generations to meet their own needs*[1]. That definition takes account of the tension that exists between the interests of current and future generations. Meeting present needs also involves potential trade-offs between economic, social and environmental goals. The fundamental goal of sustainable development, therefore, is the quality of economic growth as well as its quantity.

Figure 1: Interactions Between Economic, Social and Environmental Pillars of Sustainable Development



Source: Adapted from OECD (2001).

[1] *WCED (1987).*

Figure 1 provides a simplified representation of the main linkages between the economic, social and environmental pillars of sustainable development:

- ***The interaction between the economic and environmental pillars*** encompasses, on one side, the productive services provided by environmental resources, as well as the economic effects of measures to protect the environment. On the other side are the effects on the environment of economic activities and policies, as a result of firms' behaviour or of government interventions that harm or benefit the environment.
- ***The interaction between the environmental and social pillars*** includes the provision of environmental amenities and environmental degradation and scarcities, which may result in health hazards for exposed populations. Policies to limit this degradation may improve working and living condition and prevent civil and military conflicts. Conversely, social conditions affect the environment through consumption patterns.
- ***The interaction between the economic and social pillars*** includes the provision of human inputs to economic activities and the way in which social norms, attitudes and institutions affect the functioning of markets. Conversely, economic processes affect society, providing the foundation for greater prosperity and for financing of social security programmes, but affect the distribution of economic benefits.

Economic development objectives have historically tended to dominate government policies and the priorities of society as a whole. So the integration of the concept of sustainable development into public policymaking in practice typically involves giving greater emphasis to social and environmental concerns. This process is generally most advanced in rich countries.

Energy is implicated deeply in all three pillars of sustainable development - the economy, social welfare and the environment.

Energy is implicated deeply in all three pillars of sustainable development - the economy, social welfare and the environment. Energy services are an essential input to economic activity and to satisfying basic human needs such as food and shelter. They also contribute to social development by improving education and public health. But supplying and using energy can also have adverse effects on human health and eco-systems at the local, regional and global level. The role played by energy in each of these aspects of sustainability is discussed below.

2.2 ENVIRONMENTAL SUSTAINABILITY

The environmental side effects of energy production, supply and use are widely recognised. The production, distribution, supply and use of energy are responsible for much of the environmental degradation on a global scale (Table 1). In the past 100 years, many of the energy-related environmental phenomena have grown from local perturbations to global disruptions, driven by a 20-fold increase in the use of fossil fuels and a tripling of the use of traditional sources of energy such as biomass.

Table 1: Environmental Impact of Selected Emissions by Sector, Mid-1990s

Source	Environmental impact	Share (%) of human disruption to environment caused by		
		Commercial energy	Traditional energy	Other
Oil added to oceans	Local sea/land pollution	44	Neglible	56
Lead emissions (air)	Local air pollution	41	Neglible	59
Cadmium emissions (air)	Local air pollution	13	5	82
Sulphur emissions (air)	Regional land/water/air pollution	85	0.5	14
Methane emissions (air)	Risk of global climate change	18	5	77
Nitrogen fixation as nitrogen oxide and ammonium (air)	Regional air pollution and global climate change	30	2	68
Mercury emissions (air)	Regional air pollution	20	1	79
Nitrous oxide emissions (air)	Regional air pollution and risk of global climate change	12	8	80
Particulate emissions (air)	Local air pollution	35	10	55
Non-methane hydrocarbon emissions (air)	Regional air pollution and risk of global climate change	35	5	60
Carbon dioxide emissions (air)	Global climate change	75	3	22

Source: Adapted from UNDP/UNDESA/WEC (2000), p64.

Environmental impact occurs at several levels depending on the type of fuel and the way in which is produced or consumed:

- At the ***household and workplace level***, the use of solid fuels (biomass and coal) for cooking and heating in simple devices can produce large amounts of air-borne pollutants, which can cause serious health problems. Indoor pollution from fuel use is thought to account for as much as 4-5% of global disease[2]. Women and children generally suffer the most.

In the urban conglomerations of many developing countries, local air pollution has reached dramatic proportions.

- At the ***community or local level***, urban air pollution caused directly or indirectly by fuel combustion is the chief source of environmental disruption. Local air quality has become a major preoccupation in many countries. Pollution from industrial activities and increasingly from transportation is a major problem in many cases. In the urban conglomerations of many developing countries, local air pollution has reached dramatic proportions with massive adverse effects on the health of communities. The main eco-system effects relate to large-scale hydropower projects in forests, although surface mining causes significant damage in many areas. Harvesting of wood and production of charcoal can also have a major impact on eco-systems.

- At the ***regional level***, fine particles and ozone are probably the most widespread health-damaging pollutants from energy use. These effects can extend hundreds of kilometres from their sources. Nitrogen and sulphur emissions can also lead to acidification of lakes, forests and soils far from their sources. Energy activities account for an estimated 82% of anthropogenic emissions of sulphur dioxide and 76% of nitrogen oxides - both of which play a major role in acid deposition.

[2] *UNDP/UNDESA/WEC (2000), p62. See Box 2 for more details of the health implications of indoor use of solid fuels.*

- At the ***global level***, energy production and use carries the risk of disrupting climate as a result of emissions of heat-trapping, greenhouse gases. Climate scientists have grown progressively more confident in their understanding of the impact of energy-related emissions on climate change and their predictions of the likely magnitude of that change. Deforestation resulting from wood gathering for energy purposes, by reducing carbon sinks and leading to greenhouse-gas emissions, aggravates the risk of climate change.

The relentless rise in demand for energy services, makes the challenge of environmental sustainability both more difficult and more urgent.

Any form of energy production or consumption that occurs on a sufficiently large scale is likely to be at odds with environmental sustainability given that natural resources within the biosphere are finite. The growth of population and economic activities, which is leading to a relentless rise in demand for energy services, makes the challenge of environmental sustainability both more difficult and more urgent with time. The progress that has been made in the industrialised countries in addressing local and regional energy-related environmental problems holds out hope for developing countries. Dealing with the threat of climate change will require much more radical action. Little progress has yet been made in reducing anthropogenic emissions of greenhouse gases.

2.3 SOCIAL SUSTAINABILITY

Energy, alongside other industrial activities, plays a role in social sustainability through wealth generation and distribution and social organisation. A lack of indigenous energy resources can contribute to inadequate social advancement, notably in developing countries where insufficient access to modern energy keeps communities in poverty, hinders education and undermines quality of life. In this sense, insufficient provision of energy services may be considered socially unsustainable. Today, this is generally only a concern for developing countries. In industrialised countries, there is virtually universal access to modern energy services and social problems are rarely linked to lack of access to them.

Increased provision of modern energy services dramatically improves the quality of life in the developing world.

Increased provision of modern energy services, particularly electricity, dramatically improves the quality of life in the developing world. Access to electricity improves opportunities for education, public health and economic productivity, and increases people's access to information and telecommunications, which are essential pillars of democratic society. Women generally benefit most, because of their position in households and communities and the predominantly biomass-based energy-resource base. There are an estimated two billion people in the world who lack access to electricity, defined as availability in the village; the figure is undoubtedly even higher if access is defined as electricity supplied to homes[3]. Most developing countries face serious shortages of power generation capacity.

The transition to modern commercial energy may, nonetheless, have some short-term negative effects on the social welfare of people employed in the production and distribution of traditional fuels. Reduced employment and incomes in that sector, however, would be offset at least to some degree, if not entirely, by new jobs created in the commercial fuels sector. The new jobs would also be of better quality and better paid.

[3] *OECD (2001).*

The importance of access to modern energy to social welfare is illustrated in Table 2, by comparing demographic indicators with the share of biomass in total fuel use.

Table 2: Biomass Use and Demographic Indicators

Indicator	Biomass as % of total fuel use				
	0-20	20-40	40-60	60-80	80-100
Number of countries	70	12	14	10	16
Average life expectancy (years)	71.5	66.5	59.9	54.5	47.0
Female life expectancy (years)	74.7	68.8	62.0	56.1	48.3
Male life expectancy (years)	68.5	64.0	57.8	53.0	45.8
Female-male life expectancy gap	6.2	4.5	4.2	3.1	2.6
Infant mortality (per 1000 live births)	22.5	46.6	64.7	82.6	116.8
Under-five mortality (per 1000 live births)	27.5	59.3	93.0	135.3	173.0
Total fertility rate	2.5	3.3	4.6	5.3	6.3
Crude birth rate	19.2	26.2	35.0	39.1	45.0
Crude death rate	8.6	7.6	10.9	12.8	18.1
Annual population growth rate (%)	1.0	1.6	2.4	2.7	2.5

Source: UNDP/UNDESA/WEC (2000), p53.

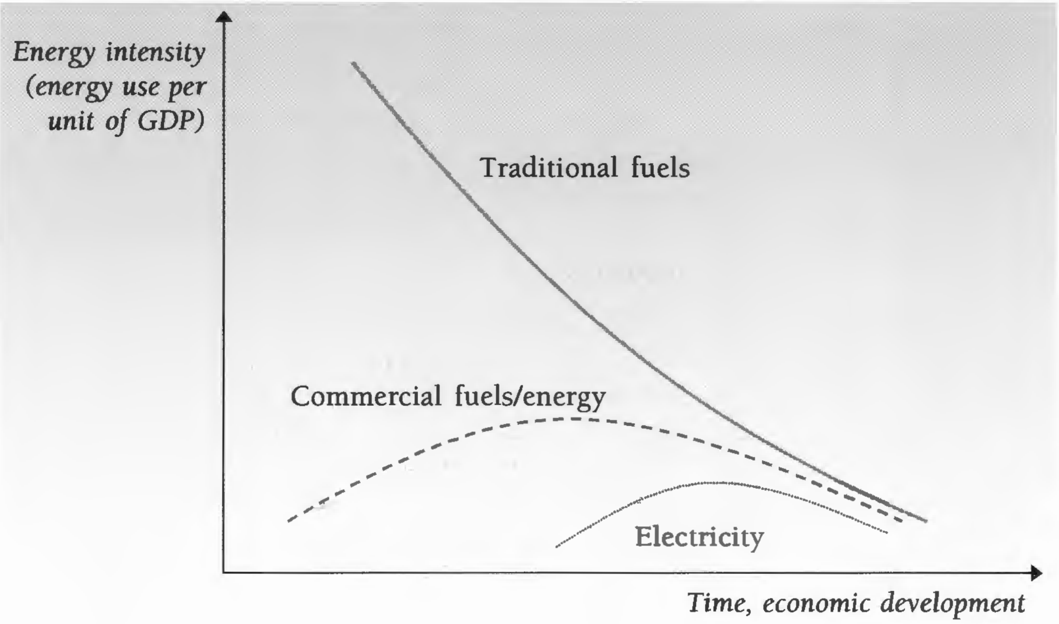
2.4 ECONOMIC SUSTAINABILITY

Economic growth - a primary developmental objective - implies increased provision of energy services, which in turn requires increased primary use of energy resources. But the relationship between economic growth and energy use, while robust at the aggregate level, is neither static nor uniform across regions and sectors. Energy intensity - the ratio of energy demand to GDP - depends on, among other things, a country's stage of economic development.

Detailed, long-term analysis of energy demand trends across countries and regions reveals that energy intensity tends to fall over time, although comparative advantages in energy resources (which tend to attract highly energy-intensive industries) give rise to differences across countries. There are three separate, overlapping phases in the evolution of energy use (Figure 2):

- A shift from traditional to modern fuels.
- An increase in the efficiency of energy use.
- Substitution of electricity for direct fossil fuels uses for many energy services.

Figure 2: Long-term Evolution of Energy Intensity



Source: IEA/OECD (1997).

The shift to modern fuels initially leads to an increase in energy intensity through industrialisation, improved comfort levels and increased personal transportation and freight. As industrialisation proceeds, structural changes, including a shift to service activities (which is less energy-intensive), cause energy intensity to peak and then decline.

Most OECD[4] countries have already reached this stage. Economic development eventually leads to saturation in demand for bulk, industrial goods and increased demand for smaller, more energy-efficient miniaturised products. Technological advances raise the average energy efficiency of equipment and appliances and reinforce the long-term declining trend in intensity.

Energy intensity varies widely among regions according to structural, climatic, demographic and cultural factors as well as energy prices and taxes. North America has a much higher energy intensity than Europe, which in turn is significantly more intensive than Japan. The transition economies (the countries of the Former Soviet Union and eastern and central Europe) are among the most energy-intensive regions, due mainly to climate and inefficient energy use in all end-use and transformation sectors - a legacy of the Soviet era.

The establishment of more efficient markets in the energy sector through competition, a process commonly referred to as market reform, is expected to enhance the long-term potential for economic development. The reform process, which began in the 1980s in the industrialised countries, is far from complete. The implications for the social and environmental dimensions of sustainable development are complex, but are likely to work through four main channels:

[4] *The member countries of the Organisation for Economic Co-operation and Development (OECD) are as follows: Austria, Australia, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.*

- The absolute level of energy demand, indirectly via higher economic growth (due to lower energy input costs) and directly via lower prices.
- The technical efficiency of energy production and transformation.
- The fuel mix in primary energy supply and power generation.
- The creation of new energy markets and services.

2.5 REGIONAL DIFFERENCES IN DEVELOPMENTAL PRIORITIES

Each country's developmental priorities tend to vary according to its level of economic and social development. The rich, industrialised countries that make up the OECD are relatively homogeneous with respect to their stages of economic and social development, industrialisation and institutional maturity (including the rules of law and market-based mechanisms). In those countries, the primary focus of sustainable energy development is on balancing the goal of continued economic growth and rising prosperity on the one hand and minimising the energy-related environmental damage that results from that economic expansion on the other. In general, most OECD countries have made substantial progress in addressing energy-related pollution caused by increased economic activity, including lowering emissions of health-threatening local and regional air-borne emissions from industrial installations and, to a lesser extent, from vehicles. These achievements have usually involved considerable costs; for example, the fitting of catalytic converters in vehicles and flue-gas filters in power stations.

Countries outside the OECD are much more heterogeneous. The transition economies are highly industrialised but underdeveloped in other respects, including the institutional framework and income levels. Developing countries, which make up the remaining grouping, share problems of economic underdevelopment and widespread poverty but vary according to patterns of economic development, average income levels, income distribution and institutional maturity.

Sustainable energy development priorities consequently differ among these countries. In China and India, the two largest developing countries, the primary challenge is to meet the growing need for energy to support their rising populations and expanding economies. But mitigating the serious pollution that results from increasing energy use in the major cities is becoming a pressing concern. As both countries rely heavily on indigenous coal resources, a common long-term policy objective for both countries is to reduce pollutant emissions from coal burning by deploying cleaner technologies and by diversifying the fuel mix towards natural gas, hydropower and non-hydro renewable energy sources. Market reform and the establishment of effective investment and trade rules to attract private capital are key elements in these countries' long-term energy strategies.

The resource-rich countries of the Middle East have different economic and social conditions, and therefore developmental objectives, than the rest of the developing world. Economic diversification is the main long-term goal of the large oil producers. African countries are more diverse, comprising a number of major oil producers, coal-rich South Africa and the energy-poor and grossly underdeveloped countries of sub-Saharan Africa. The priority for the resource-rich countries is to exploit effectively those resources to provide the means to support sustainable development. The priority for the energy-poor countries is to expand access to modern fuels.

2.6 ENERGY POLICY IMPLICATIONS

Because energy matters to the environment, to social welfare and to economic development, energy policy must play a key role in achieving sustainability. Most governments now recognise that free and open markets are central to economic development. It is widely accepted that the role of government in the economic life of a country is to establish an appropriate fiscal and regulatory framework that seeks to promote social and environmental goals and correct market failures. Once that framework is in place, consumers and producers should be free to make informed economic choices according to their own objectives.

Governments have a responsibility to correct market failures by making sure that each polluter pays for the damage he causes.

Environmental degradation - such as air pollution and climate change - is a classic example of an external cost or externality. This is a type of market failure, since the market fails to put a financial value or penalty on the cost of emissions generated by households or firms. Good air quality and a stable climate are, in economists' parlance, public goods, from which everyone benefits. Governments, therefore, have a responsibility to correct these market failures by discouraging those activities that emit noxious or greenhouse gases and by making sure that each polluter pays for the damage he causes to public goods. Levying charges on polluting activities is effectively a way of internalising these environmental externalities, although placing a financial value on them is bound to involve a large degree of judgement. A pollution-permit trading system, which places a value on emissions within a regulatory framework that limits the overall level of emissions, is an alternative approach. In principle, such a system can bring about emission reductions at least cost[5].

It is clear that, without proactive government policies and measures, most countries will continue to develop along unsustainable energy paths. Primary energy use is expected to grow steadily over the next decade or two at least, unless drastic action is taken. The International Energy Agency, for example, currently projects a 57% increase in global energy consumption over the period 1997-2020, on the assumption that no new policies to deal with climate change beyond those already announced up to mid-2000 are adopted[6]. Around 90% of incremental energy needs over this period will be met by fossil fuels. Most of the incremental demand will occur in developing countries, especially China and India. As a result, commercial energy demand outside the OECD, which today represents 46% of the world total, exceeds that of the OECD region by around 2010. These projections imply an increase of almost 60% in global energy-related CO_2 emissions from 1997 to 2020. The 2000 ***World Energy Assessment*** similarly predicts that primary energy use will continue to grow and that the world will rely primarily on fossil fuels for several decades to come[7].

Achieving energy sustainability, therefore, requires a radical change in present trends. This will involve the progressive de-carbonisation of the energy mix, diversification of energy supplies (by type of fuel and geographic source) and a reduction in the energy intensity of economic activity. This will not happen unless governments adopt effective policies and measures, including a range of regulatory and economic (or market-based) interventions.

No country can expect to achieve a fully sustainable energy system in the near future.

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[5] *IEA/OECD (2001c).*
[6] *IEA/OECD (2000).*
[7] *UNDP/UNDEA/WEC (2000).*

The world will continue to remain dependent on fossil fuels for the bulk of its energy needs for at least the next two or three decades.

The world will continue to remain dependent on fossil fuels for the bulk of its energy needs for at least the next two or three decades. While their use can support economic and social development, fossil fuels are not environmentally benign. They will, however, play an important role in the transition to a truly sustainable global energy system until such time as affordable and environmentally acceptable renewable energy technologies become available.

There is no single, prescriptive model that all countries should follow. The right approach, if one exists, must take account of local market conditions, structural and institutional characteristics and changing circumstances. Efficient, but well-regulated energy markets should provide the foundation upon which government policies should be superimposed. Getting market signals right so that prices reflect the true costs of producing and consuming energy should be a key guiding principle in all cases. In this way, the economic costs of meeting sustainable development goals will be minimised. A summary of the IEA's policy principles for achieving sustainable energy development is outlined in Box 1.

Box 1: Governments Actions to Promote a More Sustainable Energy Future

The International Energy Agency, in a formal ministerial statement, has identified a number of ways in which Member Governments can seek to create the conditions for ensuring the energy sector makes the fullest possible contribution to sustainable development. These include, but are not limited to:

- *Promoting further improvements in energy efficiency*, along with further development and diffusion of non-fossil fuel technologies, including renewable energy sources.
- *Ensuring that energy markets operate in a competitive and transparent manner with minimum distortions*. As prices shape behaviour and technology, price signals reflecting full costs should reach consumers. This will entail the gradual elimination of environmentally harmful subsidies. Reduction of trade and tariff barriers will help markets operate openly and competitively and improve confidence in the marketplace.
- *Creating a stable framework for decision-making*, one that includes clear signals to the market. Incentives, regulatory measures and standards will be needed to stimulate sustainable choices in a marketplace that is still economically imperfect.
- *Continuing to liberalise energy markets with frameworks to protect the environment and enhance social welfare*. These frameworks should be stable and predictable, and promote open and competitive energy infrastructure.
- *Sponsoring energy research and development and encouraging the systematic introduction of the best technological solutions* where energy investments are made. Replacement of and new additions to the capital stock offer important opportunities for increasing the use of cleaner, more efficient energy.
- *Participating in a global effort to provide electricity to those currently without access*, through the development of and diffusion of technologies and the development of stable legal, fiscal and energy policy frameworks, particularly in developing countries, that stimulate the flow of private capital.
- *Ensuring high safety standards* in the operation and maintenance of energy equipment, plants and infrastructure, and putting in place appropriate mechanisms to respond to potential accidents.

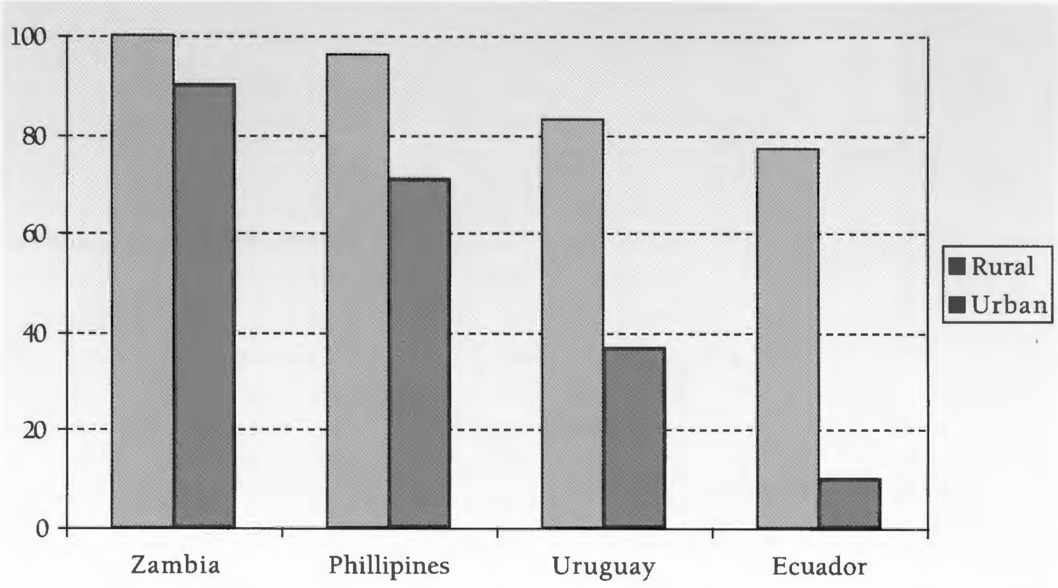
Source: IEA (2001), p233-236.

3 ENERGY USE IN DEVELOPING COUNTRIES

3.1 ENERGY CONSUMPTION PATTERNS

Developing countries[8] rely much less on modern, commercial fuels than the OECD countries or transition economies. It is estimated that around one-quarter of all energy consumed in developing countries is derived from the burning of wood, charcoal, crop residues and animal dung. This amounts to around 900 million tonnes of oil equivalent (Mtoe), equivalent to just under 10% of total world energy consumption[9]. A large proportion of this energy is not traded commercially. The importance of traditional fuels in the energy balance varies widely between countries: they make up 42% of total primary energy use in India and 20% in China[10]. In many countries, these fuels provide the basic energy needs for cooking and heating in the household sector, as well as for a number of low-technology commercial and small-scale industrial activities.

Figure 3 : Share of Population Using Traditional Fuels in Four Developing Countries (%)



Note: Traditional fuels are defined as wood, charcoal, crop residues and animal dung.
Source: World Bank (1996).

The share of traditional fuels in rural energy use in many countries in Africa and Asia exceeds 90%.

Most of the consumption of these traditional fuels occurs in rural areas, where around 70% of the population of developing countries live. Almost all these fuels are sourced locally. The share of wood and other traditional fuels in rural energy use in many countries in Africa and Asia exceeds 90%. Households account for an estimated 85% of

[8] *The term developing countries is used to refer to all countries outside the OECD and the transition economies. It should be noted that the level of development and average incomes in some developing countries approach or even exceed those of some OECD countries and transition economies.*
[9] *IEA/OECD (2000), p58-59.*
[10] *IEA/OECD (2001a), p201.*

total rural energy use in developing countries[11]. In some countries, for example in Africa, the consumption of wood and charcoal in urban areas is also very high. The energy services from these fuels are usually provided via rudimentary and generally highly inefficient technologies. A comparison of the proportion of the population using traditional fuels in rural and urban areas in four developing countries in shown in Figure 3.

The supply and use of modern commercial fuels - refined oil products (including LPGas, gasoline, kerosene, diesel, heating oil and heavy fuel oil), natural gas (where available), coal and electricity - are concentrated in urban areas in low-income developing countries. This is because the cost of distributing these fuels to rural areas is high and many people there can afford them. Modern energy is used for cooking, lighting and heating in urban areas, but almost exclusively for lighting and small electrical appliances in rural areas. Most households use traditional fuels for cooking, except in the urban areas of wealthier developing countries (Table 3).

Table 3 : Use of fuels for Cooking in Selected Developing Countries (% of total fuel use by household type)

Country	Rural households		Urban households	
	Modern	Traditional	Modern	Traditional
Low income				
Cote d'Ivoire	0.6	98.3	15.8	35.3
Nepal	0.2	97.5	17.2	32.4
Nicaragua	2.1	96.9	35.2	58.0
Vietnam	0.1	96.5	3.4	57.3
Middle income				
Ecuador	-	31.6	-	3.0
Panama	-	50.6	-	1.8
South Africa	19.7	54.4	70.8	2.0

Note: Modern fuels in this survey include electricity, natural gas and LP Gas. Traditional fuels include wood, dung, thatch and straw. Source: World Bank (2000a).

3.2 IMPLICATIONS OF TRADITIONAL FUEL USE FOR SUSTAINABILITY

The extensive use of traditional fuels in developing countries is generally a manifestation of poverty, with a number of adverse implications for sustainability:

- ***Time spent gathering fuel:*** The widespread use of woodfuel and charcoal often results in deforestation and scarcity of local supplies. Consequently, people - most often women and children - can spend a long time gathering woodfuel and other forms of biomass, which reduces the time they can devote to productive agricultural activities or education[12]. This holds back economic and social development. In addition, accidents while gathering woodfuel are common.

[11] *WEC/FAO (1999).*

[12] *A study of fuel gathering in Nepal, cited in World Bank (1996), demonstrates a clear correlation between time devoted to this activity and agricultural productivity. Nepalese women can spent up to 21/2 hours a day gathering wood, fodder and grass.*

Table 4 : Dominant Fuels in Developing Countries by End Uses

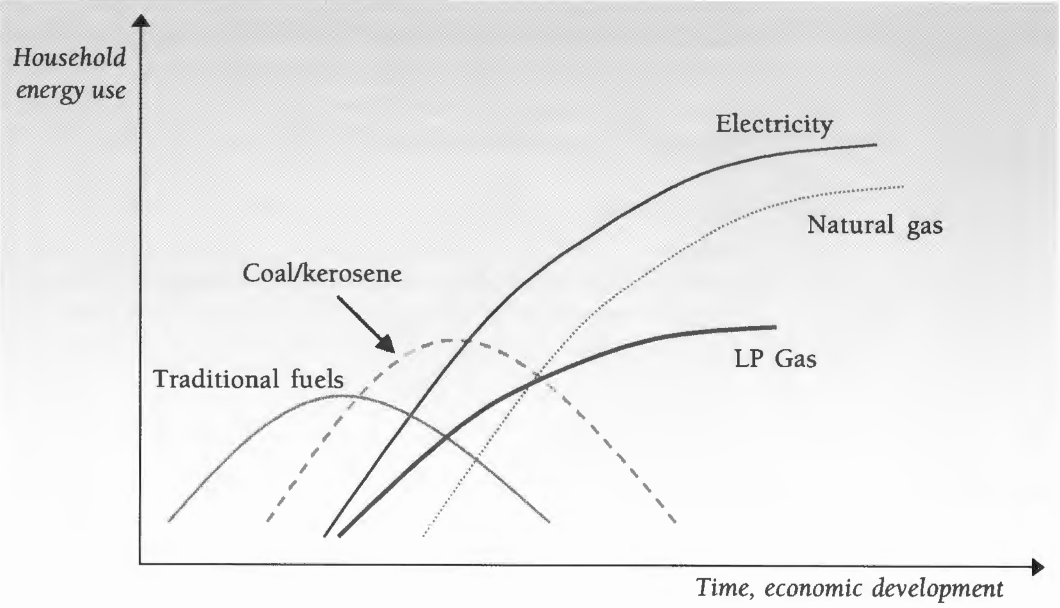
End use	*Urban areas*		*Rural areas*	
	Low income	*High income*	*Low income*	*High income*
Households				
Cooking	Wood, charcoal	LP Gas, kerosene, coal	Wood, residues, dung	Kerosene, biogas, LP Gas, charcoal
Lighting	Candles, kerosene (or none)	Electricity, LP Gas	Candles (or none)	Kerosene, LP Gas, electricity
Space heating	Wood, residues	Wood, coal, kerosene, LP Gas	Wood, residues, dung (or none)	Wood, coal
Appliances	Batteries (or none)	Electricity (grid)	None (or batteries)	Electricity (batteries or grid)
Agriculture				
Ploughing	-	-	Manual, animal	Diesel, animal
Irrigation	-	-	Manual, animal	Diesel, electricity
Food processing	-	-	Manual, animal	Diesel, electricity
Industry				
Mechanical	Manual, diesel	Diesel, electricity	Manual, animal	Diesel, electricity
Process heat	Wood, charcoal	Coal, charcoal, kerosene	Wood, residues, charcoal	Coal, charcoal, kerosene

Source: Menecon Consulting analysis, World Bank (1996).

LP Gas represents a phase in the transition to advanced modern fuels, replacing traditional fuels and kerosene.

The cycle of household-energy use is illustrated in Figure 5. LP Gas represents a phase in the transition to advanced modern fuels, replacing traditional fuels and kerosene. In most countries, this transition is virtually complete at per capita household incomes of more than US$2 000. Where natural gas becomes available through the establishment of local distribution networks as the economy matures, LP Gas is itself usually displaced to a large degree by natural gas. However, LP Gas often remains the main fuel for residential/commercial heating and cooking in areas remote from the natural gas grid. In most developing countries, the distribution of natural gas to residential customers is unlikely to become widespread for many years, if ever.

Figure 5: Household Energy-Use Life Cycle



Source: Menecon Consulting analysis.

The initial stage of switching from traditional fuels or kerosene to LP Gas in developing countries typically involves the use of a cylinder attached to a simple burner. As familiarity with LP Gas grows and incomes rise, the user may install a modern cooker inside the home, possibly with the gas supplied by rubber pipe from a cylinder placed outdoors or in a separate room. Later, hot water and/or a refrigeration system may be added. In remote rural communities, LP Gas can also be used to power electric generators, although diesel is generally a more economic option. LP Gas can also be used in conjunction with renewable technologies for decentralised power generation, to meet loads that may be beyond the capacity of the renewable system or as back-up fuel where intermittence may be a problem (Box 3).

Box 3: Hybrid LP Gas/Renewable Energy Systems in Rural Communities

Hydropower, wind and solar are the main types of renewable energy systems used in rural areas. All three technologies suffer from loss of capacity and unreliability when climatic conditions are unfavourable. Experience with these systems in rural energisation programmes shows that hybrid systems or back up from other energy sources are required for a continuous supply of electricity. LP Gas is well-placed to complement or back-up renewable systems, because of the low cost of storing the fuel and installing the gas-fired generator compared to diesel, and its environmental advantages (Section 4.2).

The Norwegian Water Resources and Energy Directorate, in partnership with industry, has developed a stand-alone hybrid photovoltaics (PV)/LP Gas system that can meet all the energy needs of an ordinary family house remote from the electricity grid. The system comprises an LP Gas-fired combined heat and power generator, PV panels, a DC/AC inverter to 220 volts, an electricity storage battery and a hot water storage tank. Deployment of this system in remote rural communities in developing countries is being investigated.

Source: WLPGA (2002, forthcoming)

Subsidy programmes can increase significantly the rate of adoption of one or more modern fuels. Lifeline rates can lower the cost of electricity for low levels of consumption, although losses incurred on selling electricity below cost can hinder the rate of expansion of the grid and thus the wider availability of electricity services in the longer term. Subsidies on LP Gas or kerosene, deployed in some developing countries, have been effective in boosting their use but can involve large costs to the national treasury (Sections 6-8).

The transition to modern fuels is a gradual process. A complete shift to the patterns of energy use seen in the industrialised countries cannot be achieved overnight. Many households in relatively rich developing countries continue to use large quantities of biomass, especially in rural areas because modern fuels are not available or are too expensive. Policies aimed at improving energy services to the poor must involve a combination of four key elements:

- Expanding the availability of modern commercial fuels.
- Improving the supply of traditional fuels in an environmentally acceptable manner.
- Enhancing the efficiency of use of traditional and modern fuels, through better appliances.
- Promoting the use of renewable energy sources, particularly in electricity generation, where economic.

Policies to improve energy access need to go hand in hand with broader economic policies to promote investment, growth and productive employment.

The transition to modern fuels, produced and used in a way that limits their environmental impact, is both a consequence and a necessary condition for achieving more sustainable development. This process supports all three pillars of sustainability: the economy, by boosting productivity; social welfare, by improving living standards and enhancing safety; and the environment, by reducing indoor and outdoor pollution. Widening access to modern fuels in the poorest developing countries is limited by extreme poverty, which keeps these countries in a vicious circle of under-development. Policies to improve energy access, therefore, need to go hand in hand with broader economic policies to promote investment, growth and productive employment - especially in rural areas.

4 THE BENEFITS OF LP GAS

4.1 CHARACTERISTICS OF LP GAS

Product Description

LP Gas (otherwise known as LPG) is the abbreviated name for liquefied petroleum gas - the generic name for mixtures of light hydrocarbons that change from a gaseous to liquid state when compressed at moderate pressure or chilled. The chemical composition of LP Gas can vary, but is usually made up of predominantly propane and butane (natural butane and iso-butane). Other compounds, such as propylene and butylene, may also be present in small quantities. LP Gas sold commercially can range from virtually pure propane to pure butane, but in most cases propane is the dominant component.

LP Gas is derived either as a by-product from crude oil refining or from natural gas or oil production. With both processes, LP Gas must be separated out or removed from the oil product or natural gas streams. LP Gas is generally liquefied for bulk storage and transportation, because its density is much higher as a liquid. This requires pressurised vessels. LP Gas is normally refrigerated for shipment by sea and storage of large volumes at receiving terminals.

Properties of LP Gas

LP Gas has a high-energy content on a per tonne basis (in a liquid state) compared to traditional fuels and most other oil products and burns readily in the presence of air giving off a hot flame. These characteristics have made LP Gas a popular fuel for household and commercial heating and cooking, for industrial processes and as an alternative automotive fuel. It is also used as a feedstock in the petrochemical industry.

The principal properties of LP Gas are outlined in Table 5. LP Gas is lighter than water as a liquid but heavier than air as a gas. In their liquid state, both propane and butane have the appearance of water with only about half the density of water. Propane and butane boil at different temperatures: propane at around -42°C and butane at close to 0°C. The gas produced when both boil (or vaporise) is invisible and has no natural odour. An odourant is usually added to aid the detection of leaks. In liquid form, the volume of LP Gas changes significantly in response to changes in temperature. Consequently, storage containers are never filled to capacity to allow expansion to take place without causing an uncontrolled release of gas or damage to the container. LP Gas is easily stored as a liquid under moderate pressure. One unit of liquid expands to about 250 units of vaporised gas.

Table 5: Typical Properties of Commercial LP Gas

Property	Butane	Propane
Chemical formula	C_4H_{10}	C_3H_8
Relative density of liquid at 15.6°C	0.57 - 0.58	0.50 - 0.51
Litres/tonne at 15.6°C	1 723 – 1 760	1 965 – 2 019
Relative density of gas compared to air at 15.6°C & 1 atmosphere	406 – 431	537 – 543
Ratio of gas volume to liquid volume at 15.6°C & 1 atmosphere	233	274
Boiling point at atmospheric pressure (°C)	-2	-42
Air required for combustion (m^3 to burn $1m^3$ of gas)	30	24
Maximum flame temperature (°C)	1 990	1 980
Octane number	92	<100

Source: WLPGA (2001b).

LP Gas burns cleanly in the presence of air due to its simple chemical composition. The flammable range of LP Gas is a mixture of between 2% and 10% gas in air. This mixture needs for propane around 24 times and for butane 30 times the same volume of air for complete combustion, which means that LP Gas needs adequate ventilation for it to burn cleanly.

LP Gas Supply Chain

LP Gas is derived from two sources: from the processing of natural gas streams produced either alone or in association with crude oil, and from crude oil refining. LP Gas is automatically produced in both cases, although the primary motive for gas processors and refiners is the production of natural gas and high-value oil products such as gasoline. The major international oil and gas companies and large state-owned national producers, notably in the Middle East, dominate both gas processing and refining.

Natural gas, when extracted from a gas or oil field, is composed of methane and other hydrocarbons known as natural gas liquids, including ethane, propane, butane and small quantities of pentane and hexane. Natural gas contains a number of impurities such as water, sulphur compounds and nitrogen. Before the gas can be stored or transported by pipeline or ship (in a liquefied form), it must be processed to remove most of the impurities and to extract most of the NGLs. This is partly because they have higher economic value as separate products and partly because of the technical problems in transporting and storing the gas if they were left in. After processing, the NGLs are stored in liquid state under pressure or refrigeration. Butane becomes liquid at -2°C, propane at -42°C and ethane at -89°C. The amount of butane and propane in natural gas, or the "wetness" of the gas, typically varies within a range of 1-3% of the unprocessed gas stream in energy terms.

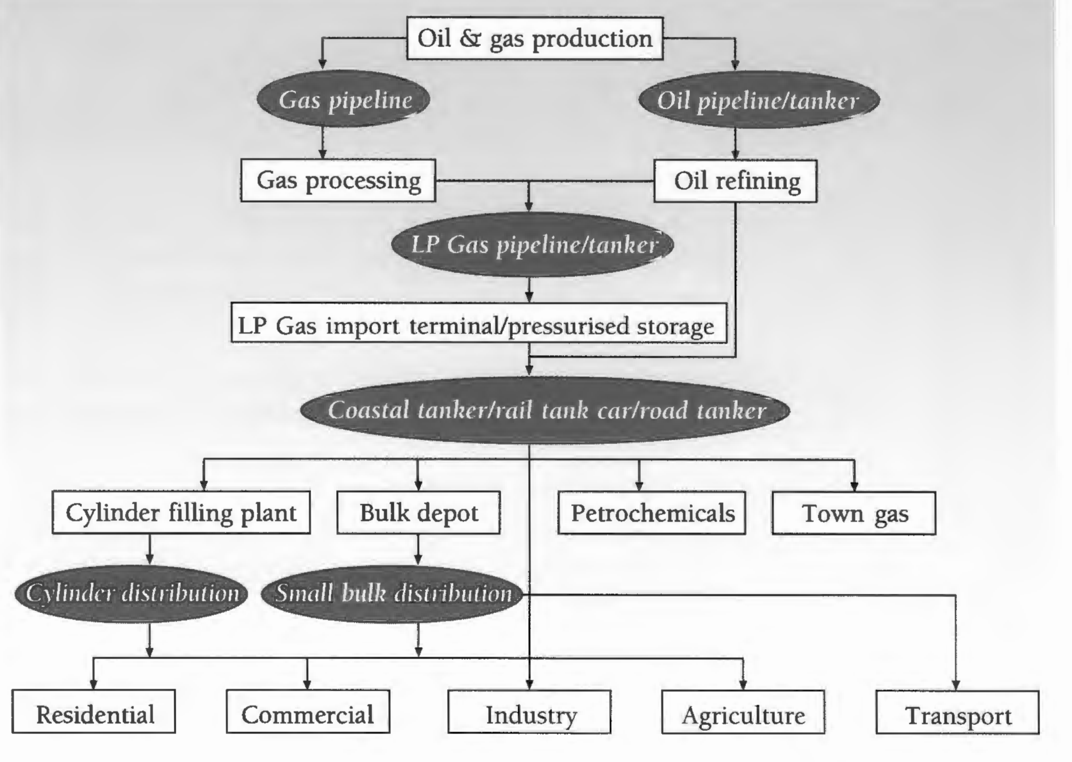
The extraction of LP Gas from crude oil involves the same principles as gas processing. Propane and butane are produced in the different stages of crude oil processing, including distillation, reforming and cracking. Some processes such as catalytic cracking produce compounds such as propylene and butylene, which may be blended into the LP Gas streams. LP Gas may also be used inside the refinery as fuel gas or as feedstock from some processes such as alkylation. The share of butane and propane in the total net output from crude oil refining varies according to the type of crude oil, the configuration of the refinery and the way it is operated. It averages about 2-3% in energy terms. Depending on the flexibility of the refinery, it is usually technically possible to increase the LP Gas yield substantially, but there must be a price incentive for refiners to deliberately do so.

Natural gas processing currently accounts for roughly 60% of total marketed LP Gas supply and crude oil refining for the remaining 40%.

Worldwide, natural gas processing currently accounts for roughly 60% of total marketed LP Gas supply and crude oil refining for the remaining 40%. This ratio varies between regions and countries. Total NGL production in 2000, of which propane and normal butane account on average for around 40%, amounted to around 340 billion litres. North America accounted for 45% of the world total[14].

Figure 6 describes the LP Gas supply chain from the point of production at the oil or gas field to the point of final use. LP Gas supply and distribution infrastructure can be independent of refineries. In the case of imports, LP Gas is usually transported by sea over long distances (usually from a gas-processing plant) under refrigeration. For short distances, which is often the case for refinery-produced LP Gas, it is more economical to ship the gas in a pressurised state. It is moved inland from the import terminal, gas-processing plant or refinery by special tanker and stored under pressure (or, in some cases, in refrigerated tanks). Storage facilities include underground caverns and cylindrical or spherical metal tanks. LP Gas can be transported inland in bulk by barge, pipeline, rail tanker and road tanker. Each means of transport requires keeping the gas under pressure to maintain it in a liquid state.

Figure 6: LP Gas Supply Chain



Source: Menecon Consulting analysis/WLPGA (2001b).

[14] *Oil and Gas Journal (25 June 2001).*

Where end-use applications involve large quantities of LP Gas, the fuel is normally delivered by road tanker and stored in bulk facilities at the customer premises. Road tankers vary in size from as little as 1 tonne to over 20 tonnes. They must comply with strict standards of design, construction, operation and maintenance given the potential hazards associated with the transportation on public roads of an inflammable product in pressurised tanks. Similarly, strict procedures are applied to the loading of the road tanker and unloading at the customer premises. Sometimes the on-site storage facilities are owned by the bulk supplier through a loan or lease arrangement.

Distributors supply LP Gas to small end-users, such as households and small commercial premises, in cylinders[15]. Distributors may deliver directly to the household or to a local retail outlet for collection by the end user. Normally, the customer is required to pay a deposit to cover the cost of the cylinder. The customer returns the cylinder when empty and obtains a full replacement. The distributor is responsible for maintaining the cylinders in a safe condition and withdrawing defective cylinders from circulation.

The global LP Gas distribution industry is highly fragmented. International oil companies and state-owned national enterprises account for about half of final sales. Independent marketers - which include the largest single LP Gas distributor, SHV, as well as some very small local businesses - make up the other half. Among the major international oil and gas companies, Shell, Repsol YPF, Total Fina Elf, BP and Agip, hold significant market shares and generally have wide market coverage. These companies are vertically integrated, with involvement in the production, bulk shipping and inland distribution of LP Gas. Some companies, especially the independent distributors, have significant market shares in only one or two regions. These companies typically buy bulk LP Gas supplies delivered to an import terminal and handle solely the inland distribution of the product.

Main Applications

LP Gas is used as an energy source in all end-use sectors: the residential (household) and commercial sectors, industry and transportation. The main energy applications in each sector are as follows:

- ***Residential sector:*** LP Gas is well suited for cooking, and space and water heating. In some developing countries, it is also used for lighting where electricity is not available. In developed countries, it may be used for outdoor activities such as barbecues and camping.
- ***Agriculture:*** LP Gas is used to increase the production and the quality of farm products through weed flaming, crop harvesting and crop drying. It is also used to heat breeding houses for pigs and poultry and power farm equipment such as irrigation pump engines.
- ***Commercial sector:*** Applications include commercial cooking (restaurants and small and large-scale catering), and water and space heating in offices and other commercial premises.

[15] *In rare instances, LP Gas may be distributed to final consumers by pipeline. LP Gas may also be used to boost the calorific value of gas manufactured from coal, as in some parts of Japan.*

- ***Industry:*** LP Gas is used in a wide range of industrial processes and activities, notably where a high degree of precision and flexibility in process temperatures - as well as a strong flame - are required. Common applications include heat treatment furnaces, direct firing of ceramic kilns, glass working, textile and paper processing, paint drying and cotton singeing. LP Gas can also be used as back-up fuel for electricity generators, including hybrid renewable energy systems in rural locations (Section 3.3).
- ***Transport:*** LP Gas is increasingly used as a low-emission alternative to traditional road-transport fuels such as gasoline and diesel for taxis, buses and private cars[16].

LP Gas is also used in the petrochemical industry, as an alternative feedstock to ethane, naphtha and middle distillates in the production of ethylene, the main bulk petrochemical intermediate product used in the manufacturing of a wide range of plastics and specialist chemicals. The other main non-energy uses of LP Gas are as an aerosol propellant and refrigerant. By replacing ozone-depleting chlorofluorocarbons in both these uses, LP Gas can contribute to sustainable development.

4.2 ADVANTAGES OF LP GAS OVER OTHER FUELS

LP Gas has a number of practical and environmental advantages over other fuels. The physical properties of LP Gas enable significant amounts of energy to be transported easily as a liquid under moderate pressure in specially designed bottles. This portability makes it particularly suitable for applications in remote locations that cannot economically be supplied with natural gas via a pipeline network. Its high calorific value in liquid form reduces transportation costs and makes it easier to handle than traditional fuels and coal. For example, a 13-kilogramme bottle provides around 180 kWh of energy; 25 kg of coal and 91 kg of wood would be needed for the same amount of energy.

In use, LP Gas shares similar advantages as natural gas. Because it is a clean-burning fuel, it can be used in direct contact with food and fragile articles such as ceramics.

The environmental benefits of switching to LP Gas from traditional fuels and most other fossil fuels can be considerable.

The environmental benefits of switching to LPGas from traditional fuels and most other fossil fuels can be considerable. It produces virtually no soot (particulate matter, PM) and, relative to most other non-renewable fuels, low emissions of carbon monoxide (CO), unburned hydrocarbons (HC) and oxides of nitrogen (NO_x) - the principal precursors of ozone, which produces smog. There are negligible emissions of toxic gases that can cause serious health problems if breathed in close to the point of combustion, which makes LPGas highly suitable as a household cooking fuel. Fuel-cycle emissions[17] of CO_2, a greenhouse gas and the primary source of global warming potential, are also lower than most other fossil fuels and traditional fuels used in unsustainable ways.

Table 6 compares point-of-use emissions from the combustion of different fuels in stoves and their efficiencies based on data from a recent survey in India carried out by the US Environmental Protection Agency. LP Gas was found to be the most efficient fuel in cooking stoves after biogas. For all the categories of emissions considered in the survey, LP Gas stoves yielded the lowest emission levels with the exception of CO and non-methane organic compounds from biogas stoves. Emissions were generally much lower than for traditional fuels and kerosene.

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[16] *See WLPGA (2001a).*

[17] *Fuel-cycle analysis takes account of emissions at all stages of the fuel's production, supply and combustion.*

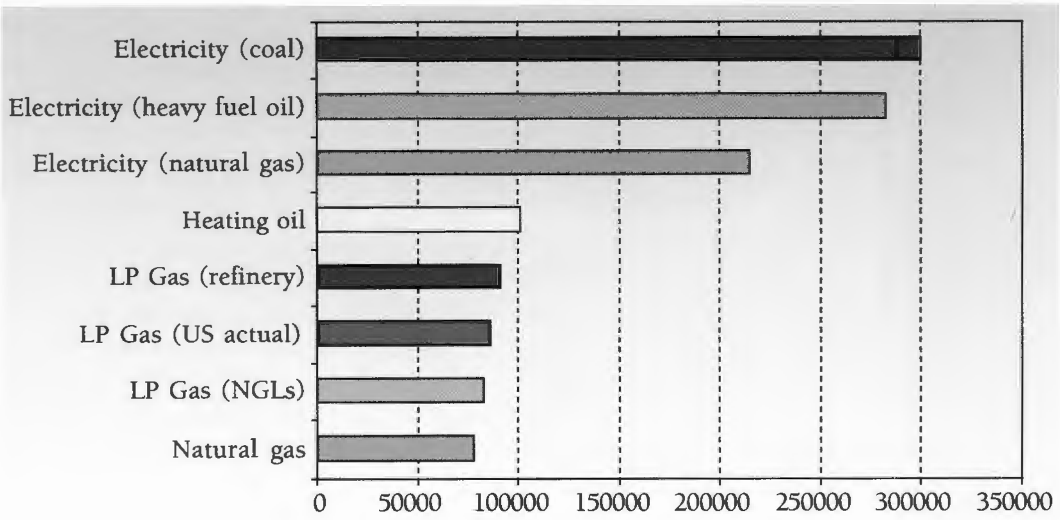
Table 6: Efficiencies and Airborne Emissions for Household Cooking Stoves, India Fuel

Fuel	Overall stove efficiency (%)	Emissions (g/MJ delivered energy)				
		CO_2	CO	Methane	TNMOC*	N_2O
LP Gas	53.6	126	0.61	Neg.	0.19	0.002
Biogas	57.4	144	0.19	0.10	0.06	0.002
Kerosene	49.5	138	1.9	0.03	0.79	0.002
Woodfuel	22.8	305	11.4	1.47	3.13	0.018
Crop residues	14.6	565	36.1	4.13	8.99	0.028
Charcoal	14.1	710	64.0	2.37	5.60	0.018
Dung cake	10.0	876	38.9	7.30	21.80	0.022

** Total non-methane organic compounds.*
Source: US Environmental Protection Agency data cited in Smith et al (1998).

A recent study of fuel-cycle emissions of urban pollutants and greenhouse gases demonstrates that for space and water heating LP Gas has lower CO_2-equivalent emissions than fuel oil and electricity generated from various sources, but slightly higher emissions than natural gas. The results of this analysis in terms of grammes of emissions per Mbtu of useful heat delivered based on 1995 data are shown in Figure 7.

Figure 7: Fuel-Cycle CO_2-Equivalent Emissions for Space and Water Heating (g/Mbtu of useful heat)



Note: CO_2-equivalent emissions include methane, N_2O, TNMOCs, CO, NO_2 and particulate matter, and are calculated using their global warming potentials.
Source: Delucci (1999).

Airborne emissions of the principal regulated noxious gases from autogas use are among the lowest of all the automotive fuels commercially available today.

LP Gas used as an automotive fuel (autogas) can also make an important contribution to improving air quality. Airborne emissions of the principal regulated noxious gases from autogas use are among the lowest of all the automotive fuels commercially available today. Autogas generates significantly lower CO, HC, NO_x and sulphur oxide (SO_x) emissions compared to gasoline and much lower particulate emissions compared to diesel in both light duty vehicles and heavy duty vehicles[18]. Overall greenhouse gas emissions are also lower than from compressed natural gas (CNG), mainly because of the latter's relatively high emissions of methane. Table 7 details the results of a recent fuel-cycle analysis of vehicle energy use and emissions from different fuels by the US Department of Energy's Argonne National Laboratory[19]. The environmental advantages of autogas over conventional and other alternative fuels are even greater with respect to unregulated emissions, including air toxics[20].

Table 7: Change in Fuel-Cycle Passenger Vehicle Energy Consumption and Emissions Compared to Conventional Gasoline (%)

	Total energy use	*Total GHGs**	CO_2	*HC*	*CO*	NO_x	*PM*	SO_x
Dedicated autogas vehicle:								
natural gas cycle	-9	-14	-15	-65	-40	-23	-45	-75
crude oil cycle	-8	-13	-13	-57	-39	-17	-35	-60
Reformulated gasoline	+2	+1	-1	-5	-19	+15	+75	0
Conventional diesel (direct injection compression)	-30	-26	-27	-62	-95	+53	+160	-30
Dedicated CNG vehicle	+4	-11	-17	-72	-43	+18	-38	-40

** Greenhouse gases, including CO_2, methane and N_2O weighted by their global warming potentials (as adopted by the IPCC).*
Source: Argonne National Laboratory Center for Transportation Research (1999).

Apart from airborne emissions from combustion, LP Gas enjoys other major environmental and health and safety benefits. Because LP Gas is transported and stored in sealed containers, there are virtually no evaporative emissions - a major problem with other liquid petroleum-based fuels such as kerosene, diesel and gasoline. LP Gas is non-toxic, so it cannot contaminate soils or aquifers. If spilt, it evaporates quickly and disperses into the atmosphere with little risk of igniting unless trapped in a confined space. This is a significant advantage compared to kerosene, a popular household fuel in many developing countries and one of the principal causes of destruction of property by fire in urban areas. Box 4 describes the health and safety problems associated with kerosene (paraffin) use in South Africa.

[18] *WLPGA (2001a).*
[19] *Argonne National Laboratory Center for Transportation Research (1999).*
[20] *See Argonne National Laboratory Center for Transportation Research (2000).*

Box 4: Health and Safety Problems Caused by Kerosene Use in South Africa

Kerosene stoves are the main cause of household fires in South Africa, resulting in the destruction of at least 20 000 homes, the death of 1 200 people and 9 000 hospitalisations due to burns every year. Burns resulting from exposed flames in households are the fourth most important cause of death for children in South Africa. Because the fuel in a kerosene stove is not sealed, it may leak and ignite when the stove is accidentally knocked over when in use. The increased use of kerosene in recent years as a replacement for wood and, in some cases coal, has led to a dramatic increase in such fires.

The use of kerosene also leads to other serious health problems. Reliable statistics on the number of hospitalisations and deaths caused by indoor pollution from kerosene stoves are not available, but they are known to be considerable. In addition, there are an estimated 100 000 cases of poisoning by accidental ingestion of kerosene, mostly by small children, resulting in 16 000 hospitalisations and 200 deaths annually. An estimated 6.5% of non-electrified households have experienced incidents of kerosene poisoning of children.

On an equal use basis, the fire-safety and indoor pollution problems associated with LP Gas use are estimated to be only a tenth of those related to kerosene. In addition, there are no cases of poisoning with LP Gas. Consequently, the Government sees the replacement of kerosene stoves by LP Gas stoves as a key element in its strategy of reducing deaths and health problems due to accidental fires, poisoning and indoor pollution.

Source: Data compiled by the LP Gas Association of South Africa; World Bank (2000a).

LP Gas enjoys other practical advantages over some other modern fuels. Because it produces a higher flame temperature than other petroleum-based fuels and the flame can be controlled more easily, it is highly suited to specialised commercial and industrial applications such as metal cutting and the brick, glass and pottery industries. LP Gas also has a very long life span. Unlike some other liquid petroleum fuels, LP Gas does not deteriorate over time when held in storage. In addition, the versatility of LP Gas allows users the possibility of using a single fuel (in addition to electricity) eliminating the need to store and handle different types of fuels.

The main disadvantage of LP Gas is the fact that it must be transported and stored in pressurised or refrigerated containers. LP Gas is by nature a hazardous product and bad handling and safety practices can lead to serious accidents. The need for special containers and for careful handling adds to the cost of distribution and storage. It also emits more CO_2 on a fuel-cycle basis than some renewable energy sources, including biomass if it is produced in a sustainable way.

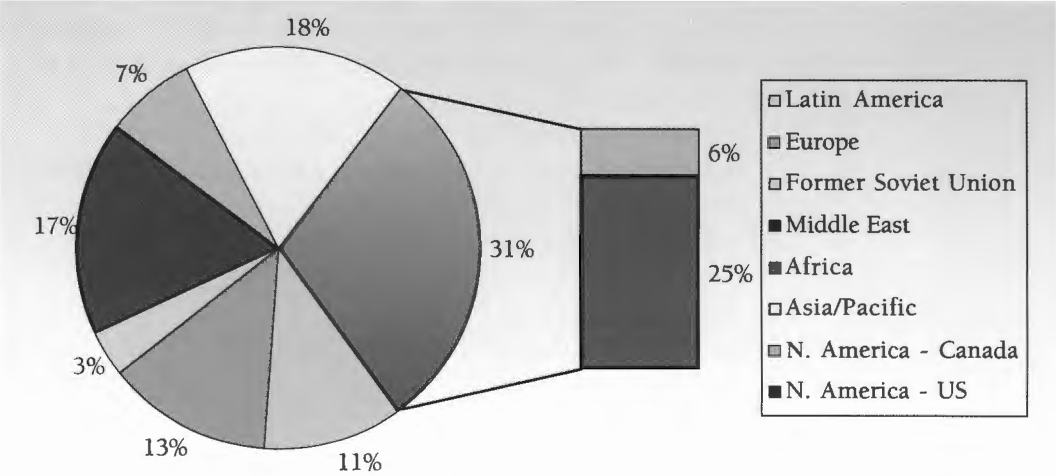
5 LP GAS MARKET TRENDS AND PROSPECTS

5.1 MARKET STRUCTURE AND HISTORICAL TRENDS

PRODUCTION

Total world marketed production of LP Gas amounted to 202 million tonnes in 2000[21]. North America is by far the largest producing region in the world, accounting for 30% of total output, and the United States far and away the largest single producing country (24%). The Asia/Pacific region, with 18% of world output, is the next largest producing region, followed closely by the Middle East (17%), where Saudi Arabia is the dominant producer. Figure 8 shows the regional breakdown of global LP Gas production. Detailed statistics on LP Gas production and consumption by country and region can be found in Appendix A.

Figure 8: Global LP Gas Production by Region, 2000

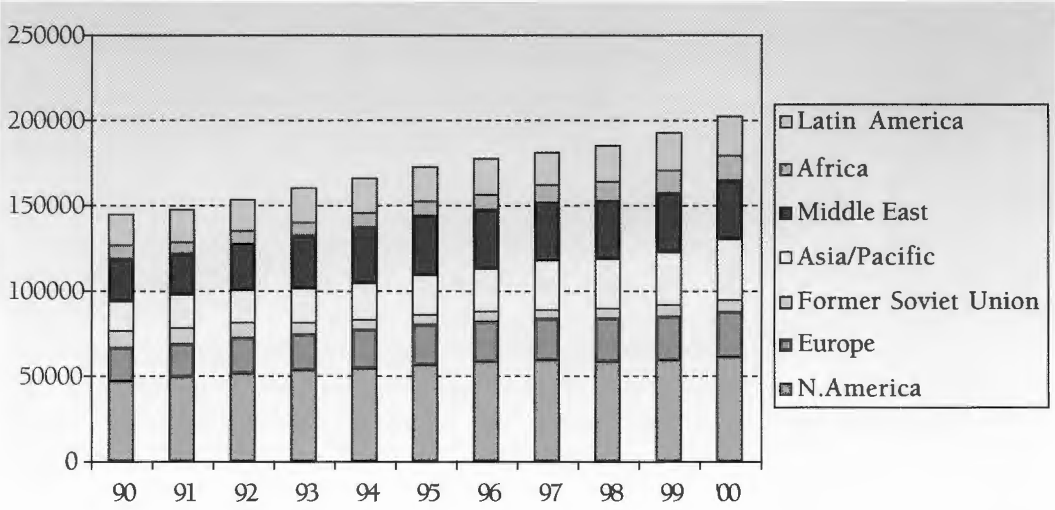


Source: WLPGA (2001c).

LP Gas production has increased in every region since 1990, with the exception of the Former Soviet Union (FSU), where crude oil refinery throughputs and domestic oil and gas demand fell sharply in the early 1990s following the collapse of the Soviet Union. Production has increased most in the Middle East and in the Asia/Pacific region, mainly due to increased natural gas processing in the former case and increased refinery runs in the latter (Figure 9). The increase in North America resulted mainly from an expansion in gas processing in Western Canada. Increased gas production and processing in the North Sea accounts for most of the increase in Europe. For the world as a whole, 87 new processing plants or expansions were completed in 2000 and 2001 compared to 44 in the period 1998-1999[22].

[21] *The data used in this report does not include LP Gas consumed within refineries (mainly as feedstock).*
[22] *Oil and Gas Journal (16 April 2001, 24 April 2000, 19 April 1999 and 13 April 1998).*

Figure 9: Global LP Gas Production by Region, 1990-2000 (thousand tonnes)

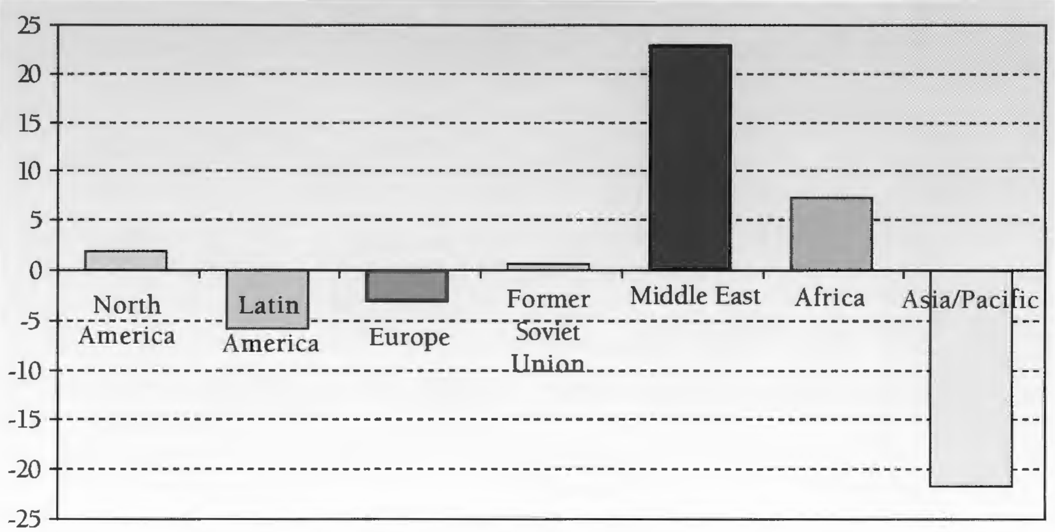


Source: WLPGA (2001c).

INTERNATIONAL TRADE

There are major regional imbalances between the production of and demand for LP Gas. Consequently, a large volume of the gas produced is traded internationally, mostly by sea. In 2000, total trade accounted for a third of global output. The Middle East is the main exporting region (24 million tonnes) and Saudi Arabia by far the largest single exporting country (12 million tonnes). Most of these exports go to the Asia/Pacific region, notably Japan, which imported almost 15 million tonnes in 1999. The high level of imports is mainly due to the low level of natural gas and oil production in the region.

Figure 10: Regional LP Gas Trade Balances, 2000 (million tonnes)*



** Exports minus imports.*
Source: WLPGA (2001c).

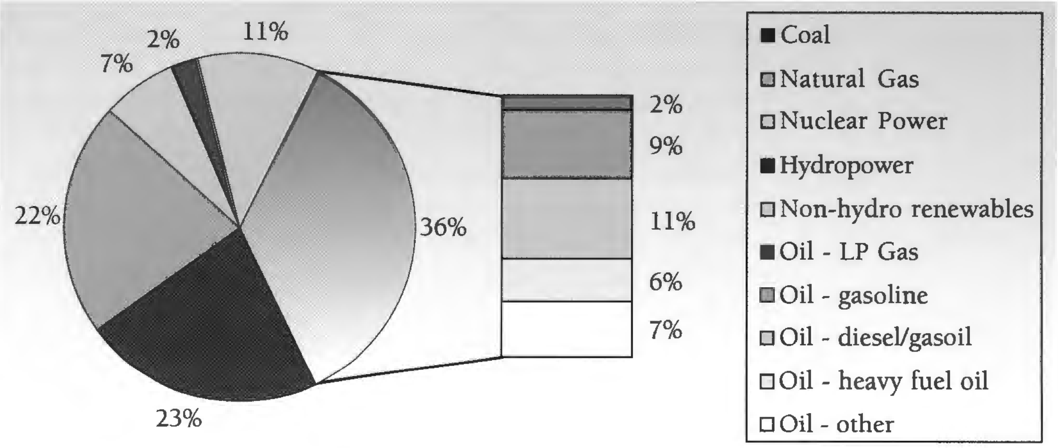
Both Europe and Latin America are net importers, with Africa the main regional supplier. Although Europe is only a small net importer, intra-regional trade is significant. This is because demand is strongest in the Mediterranean region while production is concentrated in Northwest Europe (based to a large extent on North Sea gas production). North America and the FSU are self-sufficient in LP Gas. Figure 10 shows net trade balances for each major region.

The volume of international trade has grown significantly over the last few years. The volume of imports grew by almost 9% from 1995 to 1999[23]. Rising trade between the Middle East exporting countries and the importing countries of the Asia/Pacific region account for much of this growth. Intra-regional trade has also grown significantly in Asia/Pacific, Latin America and Europe.

Consumption

Global consumption of LP Gas amounted to almost 199 million tonnes in 2000[24]. North America is the largest consuming region, accounting for just over 29% of world demand, closely followed by Asia/Pacific (a little under 29%). LP Gas accounts for around 6% of global oil consumption, which in turn is equivalent to around 36% of total world primary energy use (Figure 11).

Figure 11: Global Primary Energy Consumption by Fuel, 2000

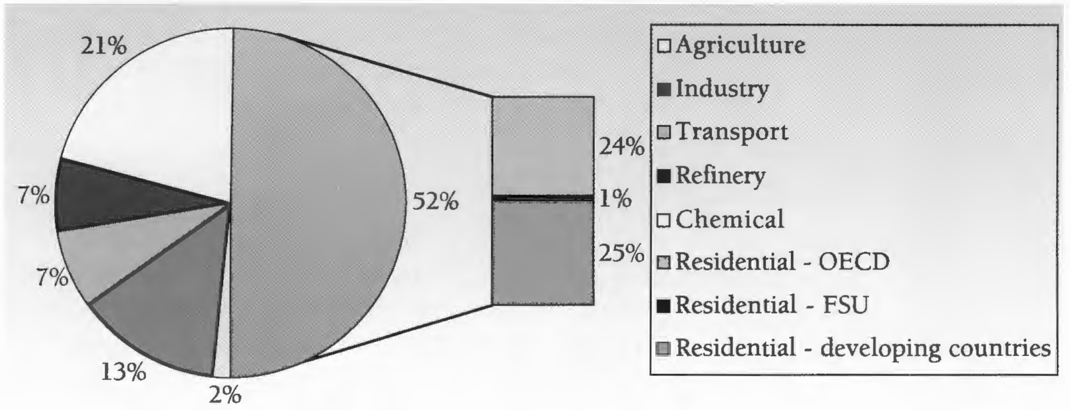


Note: In the absence of data for non-hydro renewables for 2000, their share in total primary energy for 1999 was applied to estimate 2000 consumption. Similarly, the shares of each non-LPGas product grouping in total oil consumption are based on 1999 data.
Source: BP (2001); IEA/OECD (2001d).

[23] *Datamonitor (2000), p67.*
[24] *This is marginally less than the estimated level of production. The difference is explained by stock changes and statistical discrepancies.*

The residential sector is the largest single end-use sector, accounting for approximately half of global consumption (Figure 12). The developing countries account for the bulk of residential LP Gas demand worldwide; the OECD countries consume most of the rest. Whereas LP Gas is used mainly for cooking in developing countries, it is used more for space and water heating in the OECD countries.

Figure 12: LP Gas Consumption by End-Use Sector, 2000

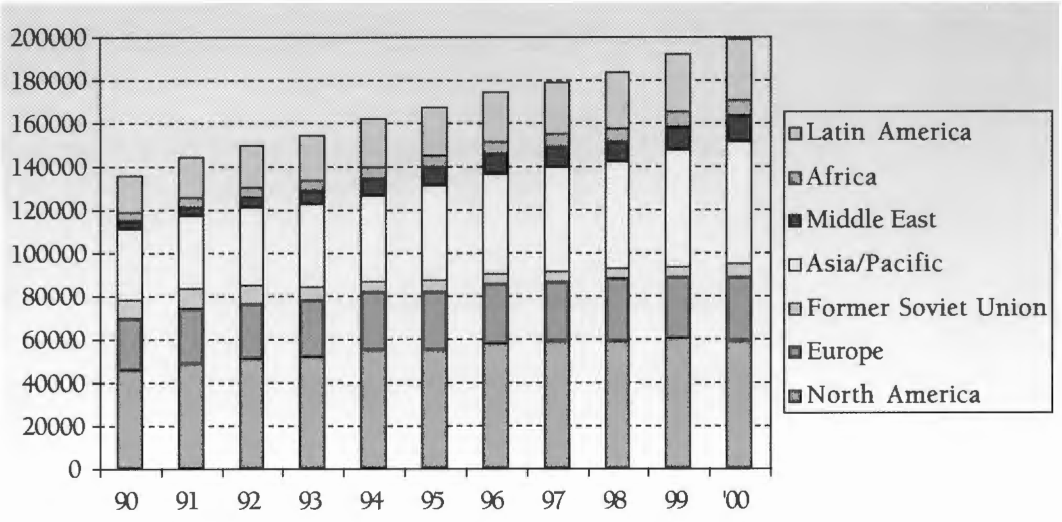


Source: WLPGA (2001c).

Global LP Gas demand has grown rapidly over the past decade, at an average annual rate of just under 4% (Figure 13). This is considerably faster than for oil products as a whole, demand for which has increased by only 1.3% per year since 1990[25]. The fastest rates of LP Gas demand growth have been in the developing regions, especially the Middle East (at an average of 12% per year from 1990 to 2000), Africa (7%) and Asia/Pacific (6%). Consumption has grown particularly rapidly in absolute and percentage terms in China, India and Korea. By contrast, demand in the mature markets of North America and Europe grew by around 2.5% per year over the same period. Demand in the FSU slumped to only 70% of its 1990 level by 2000, an average decline of about 3% per year.

[25] *IEA/OECD (2001d).*

Figure 13: LP Gas Consumption by Region, 1990-2000 (thousand tonnes)



Source: WLPGA (2001c).

The residential sector has been the fastest growing end-use sector globally in recent years, with demand rising at an average annual rate of over 4% from 1990 to 1999[26]. Most of this incremental demand came from Asia/Pacific, where consumption increased by almost 10% per year, and the Middle East. Demand has been particularly buoyant in China, growing by an estimated 26% per year from 1990 to 1999 and just under 20% from 1995 to 2000[27]. Residential demand in India has also been growing rapidly, by around 10% per year since 1990. Residential LP Gas use is growing rapidly in Africa but the volumes remain relatively small. In Latin America, demand is slowing in some countries with increasing availability of natural gas. Residential demand in North American and Europe has been growing by only around 1% per year since the mid-1990s.

Industrial demand for LP Gas has been growing at much more modest rates in most parts of the world in recent years. The Latin American market has expanded the most in the last five years, growing by 9% per year or by over 1 million tonnes from 1995 to 1999.

Automotive demand is growing rapidly is several parts of the world, although its market share remains small. Demand is strongest in Europe and in Asia/Pacific, driven by fiscal incentives and other regulatory measures to encourage the use of cleaner transport fuels. Demand in Europe has risen by more than 7% per year since 1995, thanks .to a surge in vehicle conversions in Turkey, France and the United Kingdom.

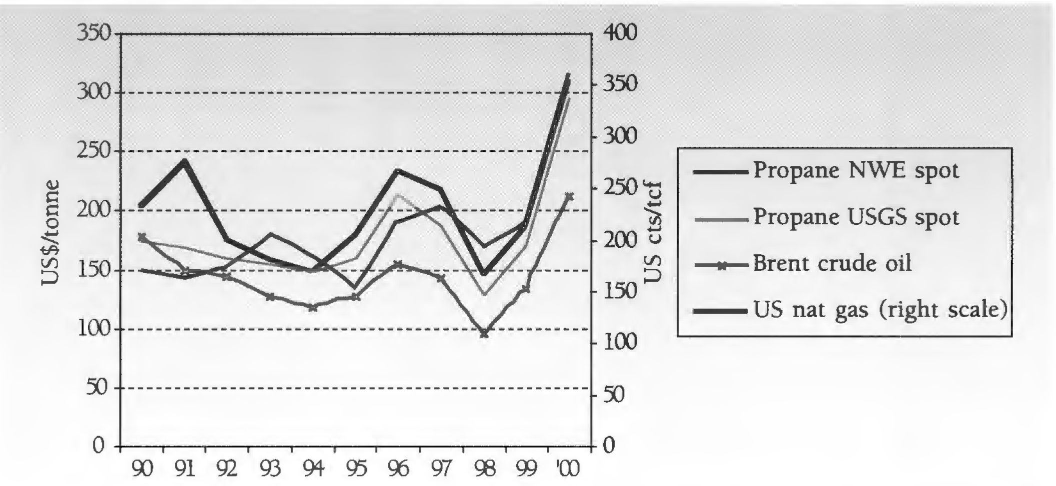
Petrochemical and refinery demand for LP Gas has been rising in line with increased consumption of refined oil products and petrochemical products. World ethylene-production capacity grew by 46% over the period 1990-1999, with developing countries accounting for most of this increase.

[26] *From a presentation by C.Whitly at the Purvin & Gurtz 14th Annual US/International LPG Seminar, Woodlands, Texas, March 2001.*
[27] *Figures include commercial use.*

PRICES

Propane and butane are traded internationally and within the large North American market on a spot basis (cargo by cargo) and under term contracts that cover a specified number of cargoes over a specified period. Contract prices are typically indexed to published spot-price quotations for LP Gas and other oil products. Spot prices and the base prices in term contracts are determined by market conditions at the time the deal is struck.

Figure 14: LPGas, Crude Oil (US$/tonne) and Natural Gas Prices (US cents/thousand cubic feet)



Note: The US gas price is a weighted average delivered to pipeline; the crude oil price is dated Brent. Source: Petroluem Argus, LP Gas World (propane prices); IEA, Monthly Oil Market Report (Brent price); US DOE/EIA, Natural Gas Annual (natural gas price).

Because of the large share of petrochemical demand in total global LP Gas demand and the volatility of demand from this sector, LP Gas prices tend to fluctuate more sharply in the short term than those of oil or natural gas. In particular, LP Gas prices tend to increase in the summer in the Northern Hemisphere, when petrochemical and refinery demand is higher because of increased demand for gasoline. Propane and butane replace naphtha as feedstock in ethylene plants, as larger volumes of naphtha are diverted to gasoline production in refineries. Over the longer term, the prices of LP Gas, crude oil and natural gas tend to be highly correlated (Figure 14).

5.2 MARKET OUTLOOK

The global LP Gas market is likely to continue to grow steadily over the next decade driven by increased upstream supply, especially from natural gas processing, and rising demand in end-use markets. But exactly how rapidly the market will expand, where incremental supplies will come from and the main growth markets are uncertain.

Key Market Drivers

A range of economic and policy factors, including price (which, in turn, is also influenced by the evolution of the market), drive both the supply of and demand for LP Gas. The main factors are summarised in Table 8.

LP Gas Supply

The principal supply-side factors are the rate at which new supplies of natural gas are discovered and developed (and the proportion of NGLs in the gas streams) and incremental crude oil refining capacity is brought on stream and utilised. The former is both a function of geology and the attractiveness to oil companies of looking for and developing gas reserves in specific locations, which in turn depends on prices and costs. The latter depends largely on refinery economics and demand trends, which determine the need for new capacity and its location.

Propane and butane prices, as well as natural gas prices, affect the level of investment in exploration and development drilling and gas-processing projects, and how quickly NGLs are developed. Similarly, the economics of oil refining, which depend on relative crude oil and refined product prices and costs, drive investment in new refinery expansions and green-field projects. Increased upstream supplies need to go hand-in-hand with investment in downstream infrastructure to transport and distribute LP Gas to end-use markets, including new ships, import terminal capacity, bottling plants and inland transportation and storage facilities. Cost developments, including the impact of technological advances and productivity gains through improved logistical and management practices, affect how rapidly these investments are realised.

LP Gas Demand

The level of economic activity is the primary determinant of demand for commercial fuels, including LP Gas.

The factors that drive the demand for LP Gas differ according to the uses to which it is put. There is, nonetheless, a set of generic factors that influence demand across all end-use sectors, notably macro-economic and demographic factors and prices. As discussed in Section 3, the level of economic activity is the primary determinant of demand for commercial fuels, including LP Gas. This applies to all regions but the link is especially strong in developing countries, where the rate of growth in demand for energy tends to match or outpace the rate of economic growth[28]. In addition to the rate of GDP growth, rates of industrialisation, population growth and urbanisation affect the level of demand for commercial fuels and the fuel mix.

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[28] *In industrialised countries, primary energy demand tends to grow in line with but at a significantly lower rate than GDP, implying a progressive decline in energy intensity (energy use per unit of GDP). This is mainly due to a shift in economic activity towards less energy-intensive manufacturing and service sectors. Progressive improvements in energy efficiency also contribute to lower energy intensity.*

Table 8: Key Factors Driving Global LP Gas Supply and Demand

Supply-side factors	*Demand-side factors*
• Sources of supply: - Rate of discovery and development of natural gas reserves and the proportion of NGLs in new supplies - Rate of growth in refinery capacity and throughputs	• General market conditions: - Macro-economic and demographic factors - Price levels (in absolute terms and relative to other fuels) and volatility - Government policies, including environmental regulations, taxes and subsidies
• Implications of levels and volatility of international and regional oil and gas prices for: - Economics of gas-field developments - Economics of natural gas processing - Investment in LP Gas supply infrastructure	• Residential/commercial sector: - Availability and comparative prices of LP Gas and competing fuels (including traditional fuels) - Government policies, including taxes on LP Gas relative to other fuels and subsidies - Weather (short-term)
• Cost developments, including impact of: - Technological advances - Logistical/management productivity gains - Competition in bottling and distribution	• Industrial sector: - Level of production in key sectors (such as glass, ceramics and food processing) - Combustion efficiency in industrial co-generation gas turbines versus steam boilers
• Government policies, including: - Investment and trade rules - Liberalisation/competition/privatisation - Upstream and downstream taxation - Environmental regulations (access to oil and gas resources and siting of facilities) - Fuel-quality regulations	• Petrochemical/refining sector: - Demand for ethylene and availability of cracker capacity - Feedstock flexibility in crackers/refineries - Competitiveness of LP Gas against other feedstock
	• Transport sector (autogas): - Government measures to promote autogas use, including tax rebates/exemptions and vehicle conversion grants - Technology for conversions and OEM fuel system, engine and tank designs

Source: Menecon Consulting analysis.

LP Gas prices, both in absolute terms and relative to other fuels, as well as the relative volatility of LP Gas prices also influence demand levels. LP Gas in all end-use applications can, in principle, be replaced by other fuels, so its price relative to competing fuels is a key determinant of LP Gas demand in both the short-term (where fuel switching is possible) and the long term (when fuel-combustion equipment and appliances can be replaced). The greater price volatility of LP Gas compared to other fuels, due its swing role in meeting petrochemical and refinery demand and the high cost of storing LP Gas, can discourage its use.

Government policies on taxes and subsidies affect retail prices of LP Gas and influence demand. Relatively low taxes or direct subsidies to LP Gas for environmental or broader developmental reasons can boost demand for LP Gas generally or in specific end-sectors, depending on how the tax regime or subsidy programme is structured (Sections 6-7). A number of OECD and developing countries give favourable tax treatment or subsidies to LP Gas used in the household sector and/or the transport sector (autogas). Environmental legislation that constrains the use, or increases the cost, of using more polluting fuels can also affect LP Gas demand.

The main factors that influence the demand for LP Gas in specific end-use applications include the following:

- ***Residential and commercial sectors:*** The long-run level of residential and commercial consumption of LP Gas in a given country or region is dependent on its availability (i.e. the distribution infrastructure in place) and the comparative prices of LP Gas and competing fuels. In the short term, demand is highly sensitive to the weather.
- ***Industrial sector:*** Production in the main sectors that use significant quantities of LP Gas, notably glass, ceramics and food processing, is the main determinant of industrial demand. The relative price of the fuel and the availability of natural gas are also important factors. Developments in the combustion efficiency of industrial co-generation gas turbines compared to the efficiency of conventional steam boilers can also influence demand for LP Gas as the primary fuel or as back-up fuel for natural gas supplied under interruptible contracts. Recent advances in the efficiency of gas turbines have increased the attractiveness of gaseous fuels.
- ***Petrochemical and refinery feedstock:*** Petrochemical demand depends on the demand for ethylene, the availability of cracker capacity, the flexibility that exists for ethylene producers to adjust their feedstock mix and the relative prices of competing feedstock. Similarly, the demand for propane or butane within refineries as feedstock for further processing into intermediate of final oil products will depend on capacity, underlying product demand and relative prices.
- ***Transport sector:*** The key factors driving autogas use are the pump price compared to other transport fuels and the cost of converting vehicles and purchasing dedicated autogas vehicles. Those countries with well-established autogas markets, such as Australia, Italy and Korea, have made the use of autogas economic and encouraged its use through favourable tax treatment of the fuel and grants for vehicle conversions or purchases. Converted vehicles make up most of the autogas fleet worldwide. The superior environmental performance of autogas compared to other fuels, especially gasoline and diesel, provides the rationale for government policies to promote its supply and use. Expanded global use of autogas in the long term will require stronger government measures and technical advances in the area of autogas fuel systems and tank design (Box 5).

Box 5: Addressing Barriers to Autogas Market Development

Despite the environmental benefits of autogas, it is faced with important barriers to market entry including the initial cost of modifying the transport fuel distribution infrastructure, producing and converting vehicles and the need to quickly establish a viable distribution network. All stakeholders - vehicle manufacturers and converters, autogas suppliers and governments - need to work together to address these barriers and make switching to autogas attractive to motorists and public vehicle operators.

Government policies are a critical element in this process. There is a wide range of options at the disposal of policymakers to promote autogas use. The main approaches that have been demonstrated to be successful include:

- Fiscal and financial measures such as excise duty exemptions or rebates, grants and tax credits for vehicle purchases or infrastructure investment and accelerated depreciation for vehicle purchases and conversions.
- Regulatory measures such as alternative fuel vehicle-purchase requirements for fleets, appropriate health and safety standards and exemptions from city-driving restrictions.
- Technology development, including direct funding for research, development and demonstration.
- Other measures such as voluntary agreements with city authorities and fleet operators on introducing alternative fuel vehicles and information dissemination programmes.

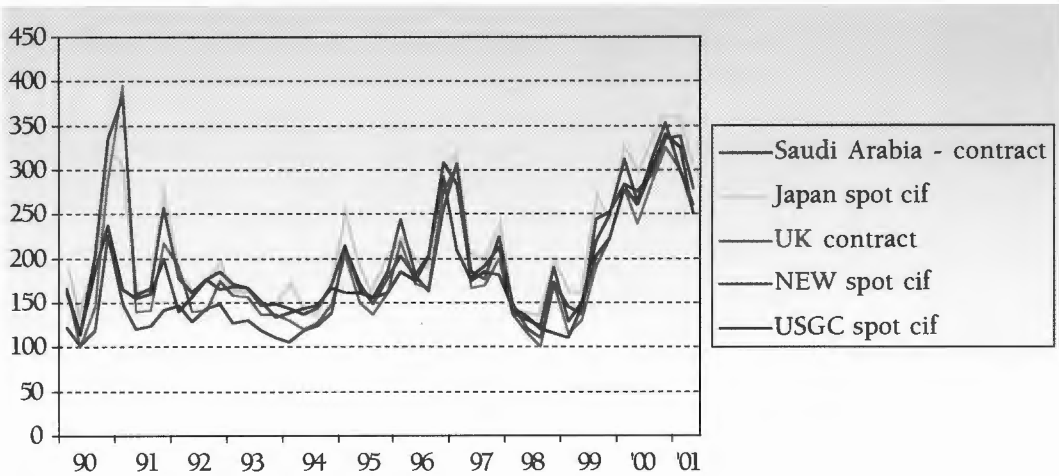
Source: WLPGA (2001a).

LP Gas Prices

How global and regional LP Gas supply/demand balances develop in response to the factors described above determine trends in propane and butane prices. The principal short-term determinants of LP Gas prices are as follows:

- ***Crude oil and natural gas prices:*** LP Gas prices tend to move in line with the prices of the fuels against which they compete. Consequently, increases in crude-oil prices, by pushing up oil-product prices generally, cause LP Gas prices to rise too. Natural gas prices usually rise (and fall) with oil prices, due to contractual linkages and inter-fuel competition. Natural gas prices also influence the economics of gas processing. Higher natural gas prices relative to LP Gas prices will, at the margin, make extracting NGLs from gas streams less profitable, and reduce the supply of LP Gas. This tends to drag LP Gas prices higher.
- ***LP Gas demand:*** In the short term, the weather and the level of demand from petrochemical producers is critical. Petrochemical sector demand for propane and butane tends to fluctuate sharply, according to the short-run economics of ethylene production and their prices relative to other alternative feedstock, such as naphtha.
- ***Shipping costs:*** The cost of long-distance sea-freight rates for LP Gas tankers can also play a significant role in short-term LP Gas price movements. Shipping LP Gas is much more expensive than other refined oil products. The level of shipping costs determines regional LP Gas spot-price differentials (Figure 15).

Figure 15: Regional Propane Prices (US$/tonne)



Source: Petroleum Argus LP Gas World (various issues).

Production and Demand Projections

The abundance of natural gas reserves and the environmental and practical advantages of LP Gas over other fuels suggest that the global LP Gas market is likely to continue to grow steadily for at least the next decade or two. As was the case in the last ten years, the supply of LP Gas will probably outstrip that of oil products generally in view of the expected rapid expansion in NGL-production capacity and strong end-use demand. The main uncertainties with regard to global LP Gas market prospects concern the geographic sources of incremental supply and the sectoral breakdown of demand growth.

Table 9: Natural Gas Reserves and Resources by Region (trillion cubic metres at 1 January 2000)

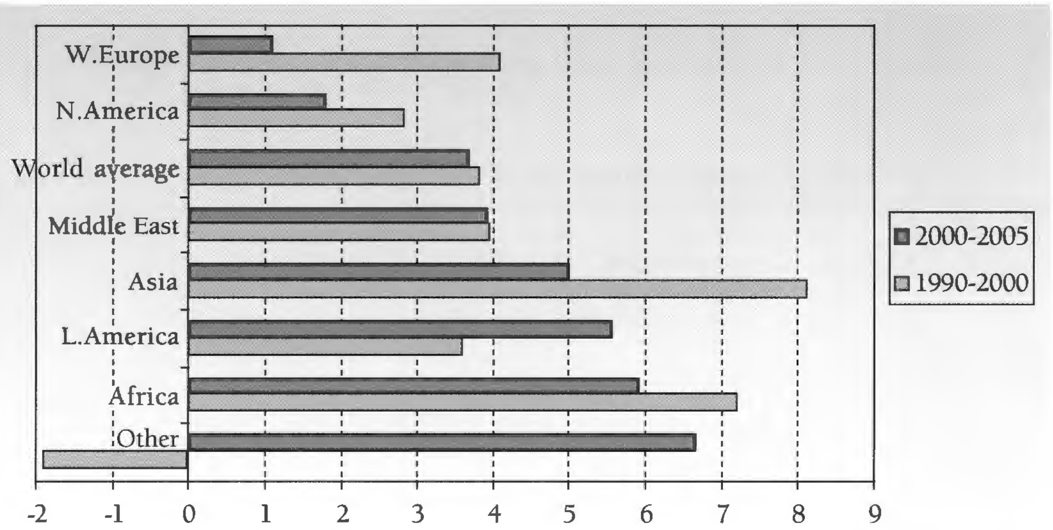
	Cumulative production	*Proven reserves*		
			Remaining	*Initial*
North America	28.3	6.2	27-34	55-62
Latin America	3.5	7.7	22-27	25-30
Europe	7.7	7.6	13-16	20-23
FSU	17.8	56.9	222-250	240-270
Africa	2.3	11.0	23-28	25-30
Middle East	4.4	53.9	115-136	120-140
Asia	3.9	14.8	31-36	35-40
World Total	67.9	158.1	453-527	520-595

Source: Cedigaz (2001).

NGLs are likely to provide most of the increase in LP Gas supply in the medium term, because natural gas demand will most likely grow faster than oil demand. The IEA, in its latest *World Energy Outlook*, projects the global supply of natural gas to grow at an average annual rate of 2.9% from 1997 to 2020, and that of oil by 1.9%[29]. Reserves of natural gas have been increasing in recent years and now exceed those of conventional oil. But the cost of transporting those reserves to market is a major source of uncertainty for how quickly those reserves will be developed[30]. Undiscovered gas resources are also extensive. Both proven reserves and potential resources are concentrated in the Middle East and the FSU (Table 9). The IEA projects gas production in those two regions to grow rapidly through to 2020, with the bulk of incremental output being exported to rapidly growing gas markets in Europe and the Asia/Pacific region[31].

Purvin and Gertz, an American consulting firm, is the principal source of detailed global LP Gas market projections[32]. It currently projects an increase in the size of the global LP Gas market from just under 200 million tonnes in 2000 to 237 million tonnes in 2005. The fastest rates of growth in production are projected to occur in Africa and Latin America through continued expansion of both natural gas processing and refinery capacity. North America and the Middle East, nonetheless, remain the largest producers worldwide (Figure 16). It should be noted that threat of a severe and prolonged recession has increased markedly since these projections were prepared and especially since the events of 11 September 2001. A recession would be expected to reduce significantly LP Gas demand growth.

Figure 16: Projected LPGas Production by Region (average annual % change)



Source: Purvin & Gertz (see footnote 32).

[29] *IEA/OECD (2000). The IEA does not project supply and demand for individual oil products, such as LP Gas.*

[30] *IEA/OECD (2001b)*

[31] *Gas production in the transition economies (including the FSU and non-OECD Europe) is projected to rise from an estimated 738 bcm in 2000 to 1 178 bcm in 2020, while Middle East output is projected to increase from 223 bcm to 524 bcm.*

[32] *The data presented here is derived from an article by A.Chandra, R.Gist, K.Otto and C.Whitley entitled LPG Trade Patterns Continue Historic Change in 2000, published in the Oil & Gas Journal, 25 June 2001; and a presentation entitled World LPG Market Overview and Outlook by C.Whitley at the 14th Annual US/International LPG Seminar, Woodlands, Texas on 19-22 March 2001 organised by Purvin & Gertz.*

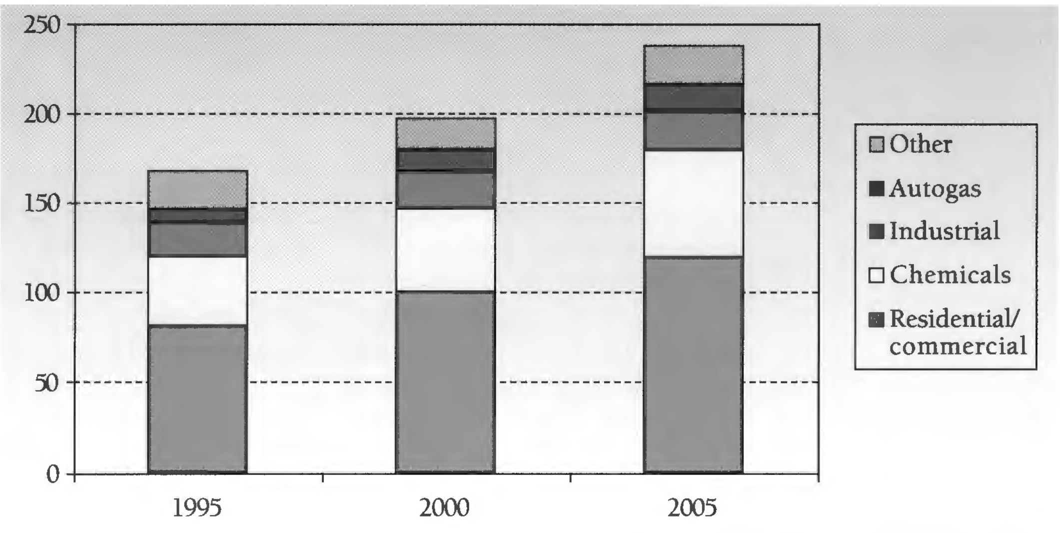
Major new gas processing projects include:

- The expansion of LNG export projects in Nigeria, which will add 1-2 million tonnes/year of LP Gas production capacity by 2005.
- New gas production in Algeria, which is expected to add 2 million tonnes/year of LP Gas production by 2004.
- New processing projects in Argentina, Bolivia and Venezuela, which should boost LP Gas output by 3 million tonnes/year, bringing total production in the region to almost 7 million tonnes by 2005.
- Several projects are under construction or planned in Asia, including processing plants based on gas from the Timor Sea, Natuna Sea and Papua New Guinea. These projects are expected to boost LP Gas production by 2.4 million tonnes/year. Other refinery and gas processing projects could also add more than 2 million tonnes/year by 2005.

Natural gas-to-liquids (GTL) projects could provide another source of LP Gas. A number of large-scale GTL plants have been proposed in Asia, the Middle East and Africa to develop gas reserves that would otherwise be stranded, because of a lack of markets.

Purvin & Gertz does not expect a dramatic change in near-term LP Gas demand-growth patterns. Global demand is projected to grow at an average annual rate of around 3.8% per year from 2000 to 2005 - slightly faster than from 1990 to 1999[33]. Most of the projected increase of nearly 40 million tonnes in consumption by 2005 will come from the residential/commercial and petrochemical sectors (Figure 17). The share of the residential/commercial sector in total consumption is expected to remain broadly unchanged at a little under 50% in 2005, while that of the petrochemical sector is expected to increase slightly to about 25%. The autogas sector increases its global market share at the expense of industrial end-uses, although its share remains modest at about 6% in 2005.

Figure 17: Projected LPGas Consumption by End-Use Sector (million tonnes)



Source: Purvin & Gertz (see footnote 32).

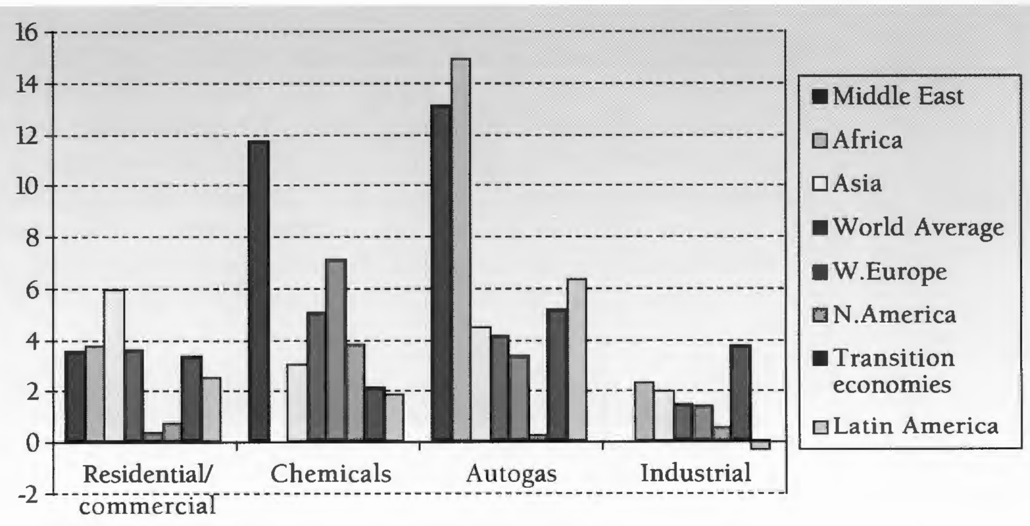
[33] *This compares to an annual average rate of global demand growth of 5.3% projected by Datamonitor (2000) excluding petrochemical uses. Datamonitor projects that the residential/commercial sector will account for 80% of the growth in non-petrochemical LP Gas consumption from 1999 to 2009.*

The developing countries are expected to continue to register the fastest rates of LP Gas demand growth to 2005.

The developing countries are expected to continue to register the fastest rates of LP Gas demand growth to 2005, although they will be lower than in the 1990s. In Latin America in particular, total demand growth is projected to slow to less than 3% per year compared to 6% over the previous decade. LP Gas demand growth turns positive from 2000 to 2005 in the transition economies on the back of economic recovery. Demand in North America continues to grow at a little under 3% per year, while demand in Europe accelerates to almost 3.5% per year, due to strong petrochemical demand.

Residential/commercial demand growth remains strongest in the developing countries, notably Asia, Africa and the Middle East (Figure 18), although the projected rates of growth for 2000-2005 are somewhat lower for over the period 1990-1999. Demand growth in Latin American slows sharply to 2.5%, while demand in the transition economies rebounds by an average of 3.3%. Residential/commercial consumption continues to grow rapidly in China and India. By 2005, the two countries are expected to account for close to a quarter of world demand, compared to less than 20% in 2000 and only 5% in 1985.

Figure 18: Projected LPGas Consumption Growth Rates, 2000-2005 (average annual % change)



Source: Purvin & Gertz (see footnote 32).

Petrochemical demand is expected to grow most rapidly in the Middle East, where a number of major new projects are under construction or planned. Ethylene-production-capacity expansions in Europe will also boost demand there by more than 7% per year. Increased availability of natural gas is expected to limit the growth in *industrial* LP Gas use in most regions, particularly in Latin America, where demand is even projected to contract slightly.

The regional trends in LP Gas production and demand projected by Purvin & Gertz imply a shift in international trade patterns. In particular, exports from the Middle East are expected to fall due to the sharp increase in petrochemical demand in that region. This factor, together with continued growth in demand in the Asia/Pacific region, means that the region east of the Suez Canal will probably need to import increasing volumes of LP Gas at least until 2002. The region became a net importer for the first time in 2000.

Imports are expected to peak at close to 5 million tonnes in 2002 and trend down thereafter, as new gas-processing capacity in Saudi Arabia boosts production of ethane for domestic feedstock use. This should free up more propane and butane for export.

As with any set of projections, the trends projected here are subject to a number of uncertainties. The most important sources of risk to these projections are the following:

- How rapidly Middle East gas-processing capacity and ethane production will increase and how quickly LPGas exports will recover.
- The rate of expansion of gas-processing capacity in Africa and Latin America.
- The impact of the global economic slowdown on demand.
- The impact of current high prices and pronounced price volatility on demand and supply prospects.
- The sustainability of high rates of residential and commercial demand growth in the key Chinese and Indian markets in the face of price deregulation and economic difficulties.

6 RESIDENTIAL LP GAS USE IN DEVELOPING COUNTRIES

Section 5 demonstrates the growing importance of residential and commercial demand (including agriculture) in developing countries in the global LP Gas market. The residential sector usually dominates total LP Gas consumption in those countries. Economic and demographic trends will most likely continue to drive rapid growth in this market segment for at least the next decade or two. But the rate of growth in different countries and regions will depend on a number of factors influencing both the availability of LP Gas and the level of demand. This section reviews the principal supply- and demand-side factors and identifies the main barriers to the growth of residential sales in developing countries, drawing on actual experiences.

6.1 LP GAS AVAILABILITY

The level of supply and the price of LP Gas in developing countries is influenced by a broad range of factors. Together these factors determine the attractiveness of investments in inland distribution infrastructure and the cost of supply to end users. These factors may be categorised as economic/market, structural and policy/regulatory.

Economic/Market Factors

The successful introduction of LP Gas into a new developing country market often depends critically on rapid growth in sales.

The potential size of the LP Gas market and the economies of scale that can be realised are a major factor in the attractiveness of investing in distribution facilities. Market potential is largely determined by demand-side factors, notably income levels and population density, which affects unit distribution costs. The importance of economies of scale means that the successful introduction of LP Gas into a new developing country market often depends critically on rapid growth in sales.

The economies of scale in supplying an isolated market are very significant, particularly in shipping and bulk storage. Small parcel sizes of imports can greatly increase the cost of shipping. In West Africa, for example, the unit cost of shipping LP Gas is more than three times higher for a parcel of 1 000 tonnes than for one of 12 000 tonnes. The cost savings are particularly large between parcels of 1 000 and 4 000 tonnes; for example, US$67/tonne compared to US$30/tonne for delivery to Abidjan in the Cote d'Ivoire from Point Noire in the Congo[34]. Parcel size is determined by the capacity of bulk storage facilities at the import terminal. The economic size of storage capacity depends on the size of the inland market and the potential for rapid demand growth. Limiting multi-port discharges by concentrating imports and storage at a single site can have a big impact on unit supply costs.

Access to local supplies of LP Gas from gas-processing plants or oil refineries can greatly reduce supply costs by avoiding the need for shipping or reducing shipping distances. The increased local availability of LP Gas, particularly from Nigeria, in recent years is one factor behind the recent expansion of some West African markets.

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[34] *WLPGA/World Bank (2001).*

Economies of scale in bulk distribution, bottling and local distribution can also be important. Where sales are large enough, bottling can be centralised in large, automated plants. Cylinder testing and re-qualification facilities can also be established alongside the filling plant, further reducing the cost of transporting cylinders, minimising human error in checking cylinders and improving safety. Cheap labour can also keep distribution costs low. In developing countries, bottling is usually carried out manually since it is more financially attractive to employ large numbers of people to carry out this task than invest in automated filling plants, although safety standards and reliability are generally not be as good.

Structural Factors

The way in which LP Gas import and inland distribution activities are structured affects investment levels, the efficiency of the industry and the potential for expanding supply. Depending on the size of the local market, industry consolidation may help to rationalise importation, distribution and bottling activities by exploiting the economies of scale discussed above. But a high level of industry concentration can also stifle competition, encourage inefficiencies and lead to higher prices. The optimal degree of concentration depends on local circumstances, most importantly the size of the market.

State companies in developing countries are very often less efficient than their private counterparts.

The direct involvement of the state in the industry can also affect the efficiency of operations, the level of investment in distribution infrastructure and LP Gas availability. State companies in developing countries are very often less efficient than their private counterparts, partly because they tend to be subject to less pressure to maximise profits. Governments often use their direct control over state firms to boost employment and lower end-user prices for short-term political and social reasons. This is particularly the case where state firms enjoy monopoly rights. State companies also tend to have more limited access to capital, which can reduce their ability to expand distribution activities, although the cost of capital may be lower.

Policy/Regulatory Factors

The public policy and regulatory framework is a key factor for a private investor in determining the level of investment risk and the required return on investment, whatever the sector. There are several aspects of the regulatory regime that affect the attractiveness of investment in developing countries, including the following:

- ***The stability of the political and legal system and the regulatory regime***. Frequent changes of government and laws governing business practices and taxation are a strong disincentive to investors, especially foreign. The more stable and favourable business and investment environment that has been established in several Latin American countries, including Argentina and Chile, has been a key factor in stimulating inward investment in the energy sector generally over the past decade or so.
- ***Currency convertibility and the freedom for foreign investors to repatriate profits*** Exchange controls and restrictions on the movement of capital are a major deterrent to investment.

- ***Trade and investment rules***. Licensing of distributors is sometimes restricted to limit competition and protect state firms. Importing and distributing LP Gas are monopolies in some countries. In most African countries, importing of LP Gas is a monopoly activity. Where there is a refinery, it often has sole responsibility for imports, such as in Cote d'Ivoire and Senegal. There are sometimes requirements to form a joint venture with a local partner. The latter is a prerequisite in several countries in Africa and the Middle East.
- ***The rate of taxation of corporate profits***. High taxes harm profitability and deter investment.
- ***Controls on wholesale and retail prices and margins***. These may be aimed at lowering or stabilising prices to protect small consumers from fluctuations in international markets, or at equalising prices across the country. If prices are consistently held below the real cost of supply, investors will only be able to make a profit if the government makes good the difference. A temporary price cap on LP Gas introduced by the Vietnamese Government in 1999 in response to rising international prices hit the profitability of distribution activities and led private foreign operators to scale back their plans to invest in new facilities. Price controls have led all the international oil companies except Total Fina Elf to pull out of LP Gas distribution in Nigeria in recent years. Where subsidies are limited to publicly owned distributors, as in India, private investors are effectively denied access to part of the market, undermining investment opportunities.
- ***The establishment and enforcement of safety and technical standards***. Safe business practices in handling LP Gas are crucial to giving confidence to consumers and investors.

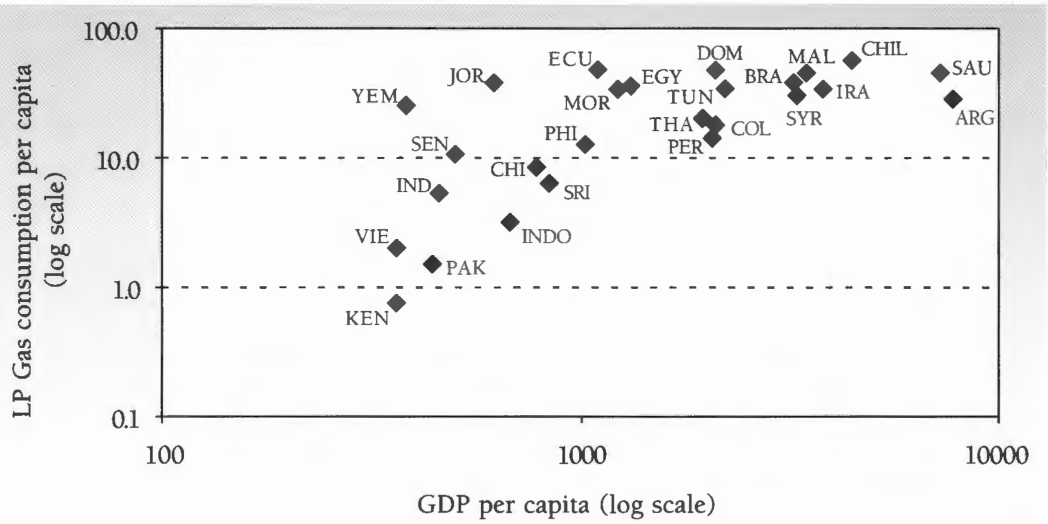
6.2 DEMAND-SIDE FACTORS

When significant numbers of households are able to afford LP Gas, demand will depend on how competitive it is against alternative fuels.

Where LP Gas is available, the main factors driving residential demand in developing countries are its affordability and competitiveness. The key determinants of affordability are household incomes and the price of the fuel. When significant numbers of households are able to afford LP Gas, demand will depend on how competitive it is against alternative fuels, such as kerosene or charcoal.

Figure 19 illustrates the strong correlation between per capita income and residential LP Gas consumption, particularly at low-income levels. The significantly higher level of per capita LP Gas use in China compared to Vietnam, for example, is broadly proportionate to the difference in per capita income. Residential LP Gas consumption appears to be inversely correlated to income levels in the three richest developing countries analysed (Argentina, Chile and Saudi Arabia), partly because of the wider availability of natural gas in the case of the first two countries. Data on per capita LP Gas consumption in selected OECD, transition and developing countries can be found in Appendix A (Table A-5).

Figure 19: Per Capita GDP (US$) and Residential LPGas Consumption (Kg) in Selected Developing Countries, 1999



Note: Consumption includes small amounts of LP Gas used in the commercial sector in some cases. Countries shown are Argentina, Brazil, Chile, China, Colombia, Dominican Republic, Ecuador, Egypt, India, Indonesia, Iran, Jordan, Kenya, Malaysia, Morroco, Pakistan, Peru, Philippines, Saudi Arabia, Senegal, Sri Lanka, Syria, Thailand, Tunisia, Vietnam and Yemen.
Source: WLPGA/MCH (2000); IMF (2001).

The level of retail prices is the other determinant of affordability. Unless it is subsidised, LP Gas is typically more expensive than other household fuels for cooking and heating (except electricity). But households tend to prefer it to other fuels because of its inherent advantages and are often prepared to pay a premium price. In developing countries, LP Gas prices are usually controlled directly by the government to keep them low or to cushion households from price fluctuations for social policy reasons. Governments may influence prices through taxation or subsidies. The pricing, taxation and subsidisation of competing fuels, by affecting their affordability too, also influences the demand for LP Gas. The sensitivity of LP Gas demand to changes in the prices of LP Gas and competing fuels depends on local market conditions.

Subsidies to the fuel itself or to LP Gas equipment (the cylinder, burner and stove) have helped to establish large LP Gas markets in several countries, including Brazil, China, India and Senegal (Section 8). Government policies can affect LP Gas demand in other ways, such as through education and awareness programmes and the establishment and enforcement of safety standards. In Brazil, for example, significant improvements in the quality of service, safety and the image of LP Gas in Brazil since the mid-1990s have helped to boost demand.

At the country level, the degree of urbanisation and density of population, through their impact on market size and distribution costs, influence the demand for LP Gas. Demand is usually stronger in highly urbanised countries, such as in Egypt and Saudi Arabia, where per capita incomes are higher and traditional fuels are expensive. Residential LP Gas use is limited to urban areas in most of China and India. High rates of urbanisation in both countries have contributed to very rapid growth in residential LP Gas demand.

6.3 BARRIERS TO LP GAS MARKET DEVELOPMENT

In some developing countries, residential use of LP Gas is limited, either because of barriers to the establishment of a viable distribution network or to the affordability of the fuel. Demand may be frustrated if LP Gas is not made available, where distributors are not willing or not able to invest in the necessary infrastructure. Effective government policies and measures can overcome these barriers (Section 7).

There are number of commercial, regulatory and institutional reasons why investment may be insufficient or may not occur, including the following:

- ***Insufficient market size or market growth potential***. This may be caused by low population density (which leads to high shipping and storage costs), lack of competitiveness of LP Gas against other fuels (possibly due to price controls or subsidy policies) or by low household incomes.
- ***Uncertainty over government policy***. This may be because of political instability or lack of consultation with industry stakeholders over future policy directions.
- ***Unfavourable rules governing investment and trade***. These include restrictions on repatriation of profits by multi-national companies and LP Gas import quotas and tariffs. The lifting of import restrictions in Cape Verde, for example, led to a surge in LP Gas use in the 1980s and early 1990s[35].
- ***An un-level playing field:*** Government policies that discriminate in favour of state-owned or national companies may discourage or prevent investment by private or foreign distribution companies.
- ***Government controls over pricing and distribution margins***. Foreign investors typically seek higher returns than in industrialised countries because of the greater risk of doing business in many developing countries.
- ***Lack of operational and safety standards or poor enforcement***. The risk of accidents undermines market growth and carries legal risks for the operators. A lack of product and cylinder standardisation can affect the safety of LP Gas transportation and use, impede cross-border trade and raise costs.
- ***Corruption***. This increases the cost of doing business and increases investment risk.

A lack of affordability due to low incomes is the primary demand-side barrier to development of residential use of LP Gas in developing countries. The potential for market expansion is usually highly dependent on the rate of increase in household income and prosperity. The phenomenal growth in residential LP Gas use in developing Asian countries since the 1980s was due mainly to rising incomes. However, in some countries, such as Indonesia, subsidies to kerosene and the ample availability of traditional fuels have undermined the growth in household LP Gas use (Box 6).

A key factor affecting affordability for poor households is the initial cost of the gas cylinder and the stove.

A key factor affecting affordability for poor households is the initial cost of the gas cylinder (either the deposit or outright purchase cost) and the stove, which tends to be more expensive than for other fuels. Overall, the initial investment cost for LP Gas is significantly higher than for kerosene, coal or charcoal.

[35] *World Bank (1996).*

These costs vary considerably across countries, according to local labour costs and the standard size of cylinder. The deposit cost (which is usually almost as high as the cost of buying it) typically falls within the range of US$10-20 for a small 6-kilogramme cylinder and between US$15-25 for a 10-15 Kg cylinder. Stoves, which cost around US$40 or more without subsidy, are much more expensive than open burners or cooking stands, which cost little more than US$5. These up-front lump-sum equipment costs tend to discourage switching to LP Gas in poor countries, where poor people may not have adequate cash reserves.

Box 6: Lowering Barriers to LP Gas Market Growth in Indonesia

Indonesia has one of the lowest rates of household LP Gas use of any developing country - around 3 kilogrammes per capita compared to over 8 Kg in China and 44 Kg in Malaysia. Woodfuel and other traditional fuels account for around three-quarters of total household energy consumption. Kerosene makes up most of the rest, with LP Gas meeting only about 1% of needs.

The low level of LP Gas use is mainly due to low-income levels. Indonesia is one of the poorest Asia developing countries, with an average per capita GDP of less than US$700 in 2000. The ample availability of biomass has hindered the transition to modern fuels, especially in rural areas and on the smaller islands. Although LP Gas is subsidised, even bigger subsidies to kerosene also undermine the competitiveness of the former. Plans to reduce kerosene subsidies and liberalise the downstream oil sector, which is currently a state monopoly, should increase investment opportunities and bolster the potential for LP Gas market growth, although political instability and structural economic difficulties may continue to discourage inward investment.

A 1993 study of the cost of meeting energy requirements for cooking in Dar es Salaam in Tanzania shows how appliance costs increase the initial cost of switching to LP Gas from kerosene, charcoal or wood and how they increase overall cooking costs (Table 10). Although LP Gas is cheaper than all the other fuels except high-quality charcoal (adjusted for differences in stove efficiency), monthly appliance costs, including the cylinder and cooker, are much higher, especially compared to kerosene. As a result, the overall cost of using LP Gas is more expensive than charcoal and only slightly cheaper than woodfuel. In this case, policies should be aimed at reducing the cost of appliances to encourage an irreversible shift to LP Gas (Section 7).

A lack of awareness on the part of households of the availability and benefits of LP Gas as well as the adverse affects on health and safety of using traditional fuels and kerosene may also hinder the use of LP Gas. In particular, many consumers are unaware of the higher thermal efficiency of LP Gas in stoves compared to charcoal or kerosene and fail to take that factor into account when comparing fuel prices. The larger minimum quantities of LP Gas than can be bought compared to charcoal and wood may also undermine the use of LP Gas, where household incomes are very low.

Table 10: Financial and Economic Costs of Cooking Fuels in Dar es Salaam, 1990 (Tanzanian Shillings)

Fuel	Fuel cost (per effective MJ)	Amortised monthly appliance cost	Total monthly cooking cost*
Woodfuel	3.94	n.a.	1 259.35
Charcoal (traditional)	3.59	22.22	1 169.81
Charcoal (improved)	2.39	125.00	890.06
Kerosene	5.24	33.33	1 709.52
LP Gas	3.17	208.33	1 224.21

**Fuel cost of providing 320 MJ of energy plus amortised appliance cost.*
Source: Hosier and Kipondya (1993).

Reliability of supply is another factor affecting demand. Regional government efforts to stabilise the supply of LP Gas in Hyderabad, India, for example, led many households to switch from biomass to LP Gas for cooking[36].

[36] *UNDP/UNDESA/WEC (2000), p372*

7 GOVERNMENT LP GAS POLICIES IN DEVELOPING COUNTRIES

7.1 POLICIES TO PROMOTE LP GAS MARKET DEVELOPMENT

Government intervention in any area of economic activity can in principle be rationalised on the basis of theoretical arguments concerning market failure or imperfections that lead to economically sub-optimal outcomes. It is for government to remedy market failures, either by addressing their causes or by trying to replicate the outcome of a perfect market. The challenge for policymakers in practice is two-fold: to find the appropriate balance between reliance on the market and intervention to address social, environmental and economic policy goals, and to find workable mechanisms that ensure that stated policy goals are met.

In practice, government support to the LP Gas sector in developing countries is justified by the important contribution the fuel can make to more sustainable energy use. By replacing traditional and intermediate modern fuels such as kerosene, LP Gas can enhance the quality of life of households and communities through reduced indoor and local pollution, improved safety and greater convenience. Expanding LP Gas use, by lowering the demand for wood, can also reduce deforestation and degradation of local eco-systems. Alongside other modern fuels, LP Gas can provide the energy needed to underpin economic development and alleviate poverty. Access to modern fuels is a necessary condition for households in the poorest developing countries to escape acute poverty.

Active government support can catalyse LP Gas market take-off and establish a virtuous circle of growing market potential, increased investment and expanded availability. Support can take various forms, including measures to make the general regulatory and business environment more favourable to investment in distribution infrastructure, subsidies to the fuel and related equipment to make LP Gas more affordable and assistance in setting up micro-credit or micro-finance programmes. These approaches are discussed in detail below.

How well an LP Gas programme is integrated into broader urban and rural energy development plans will influence how effective it is in boosting the availability and use of LP Gas. The compatibility of LP Gas policies with other policies, including structural and regulatory reforms and policies concerning health, education, infrastructure and financing, will also affect their success. Co-ordination with, and the participation of, local organisations can be of vital importance to the success of energy programmes in rural areas. Co-operatives, non-governmental organisations and local community organisations can be highly effective vehicles for supporting the establishment of local systems for energy distribution and delivery[37]. They understand much better local needs and can play a key role in communicating these needs to government, donors and external development agencies.

[37] *World Bank (1996), p35.*

7.2 BUSINESS AND REGULATORY FRAMEWORK

Private investment is crucial to expanding the supply of LP Gas and other modern fuels in developing countries.

Private investment - both domestic and foreign - is crucial to expanding the supply of LP Gas and other modern fuels (including electricity) to the household sector in developing countries. In some developing countries, political instability, an absence of institutional structures and a stable legal system, corruption and ad hoc political interventions are powerful deterrents to private investment. Several OECD countries have developed bilateral insurance schemes to address problems of political risk, although these have sometimes been costly. The Multilateral Investment Guarantee Agency, part of the World Bank Group, provides long-term investment guarantees against political risks.

In many developing countries, private investment is impeded by the dominance of state-owned enterprises, often benefiting from monopoly rights. The financial performance of these companies and, therefore, their ability to invest are often dismal. In many countries, privatisation, the setting-up of private-public partnerships with foreign and private investors and the introduction of a modern regulatory regime has boosted private investment in the LP Gas sector.

Liberalisation of LP Gas importing, wholesaling and retailing, involving the removal of exclusive rights and controls over prices or margins, can provide a powerful stimulus to the market. In much of Asia and Latin America, the opening up of the LP Gas sector to private participation and competing suppliers has had a tremendous impact on expanding supply to the household sector (Box 7). By contrast, the development of the LP Gas market has been held back in many African countries by restrictive regulations covering investment and trade.

Box 7: Impact of LPGas Market Liberalisation on Household Use in Asia

Market liberalisation has boosted residential LP Gas sales in several Asian countries:

- A number of international oil companies have established distribution and marketing operations in the booming Chinese market. These are all joint ventures, since Chinese law until recently prohibited more than 50% foreign ownership. The downstream LP Gas sector has become highly competitive since liberalisation.
- In Vietnam, a number of private distributors entered the market following market liberalisation, including the lifting of price controls, in the early 1990s[38]. The leading private distributor, Total Fina Elf, now has a 10% market share and other major oil companies, including Shell, BP and Exxon-Mobil, have established a presence. Around 75% of sales are to the household sector.
- The opening up of the LP Gas market in the Philippines in 1996 encouraged several foreign oil companies to invest there, including Shell, Caltex, Total Fina Elf, SHV and Petronas, as well as two local private companies. The market share of the privatised national operator, Petron, has fallen to about 16%. Since 1997, more than 100 bottling plants have been built and demand, almost entirely for household use, has risen by 40%.

[38] *Price ceilings were reintroduced temporarily between June 1999 and March 2001 in response to a surge in import costs.*

Where conditions are not conducive to attracting private investment, public-private partnerships may offer an alternative source of funding. This approach may also be more politically acceptable in some countries. Private investors, however, need to be reassured that political objectives and public service obligations will not harm investment returns. Examples of public-private joint ventures in the LP Gas sector include China and some Latin American countries.

7.3 SUBSIDY PROGRAMMES

Direct subsidies are the most common form of support to LP Gas in developing countries.

Direct subsidies are the most common form of support to LP Gas in developing countries. Most developing countries subsidise LP Gas, often along side other modern fuels, although many are now attempting to remove or reduce fuel subsidies. Although intended to encourage supply and promote LP Gas use, their long-term impact on consumption depends crucially on how subsidy programmes are designed and the broader regulatory framework.

Most countries that subsidise LP Gas or other forms of energy do so for social welfare reasons: they are intended to make the fuel more affordable and therefore more accessible to households, especially the poorest, or to encourage suppliers to expand its availability. Fuel subsidies are often seen as an alternative to direct income transfers, which may not be possible if the social service infrastructure needed to manage such transfers does not exist. Lowering the prices of energy and other basic items (such as food, water, shelter, clothing and education) may be the only means by which government can transfer wealth from rich households and external donors to the poor.

Forms of Subsidy

LP Gas subsidies take a variety of forms, the most common of which are price controls that keep the retail prices of the fuel or related equipment below their true market cost and direct transfers, grants or loans to consumers. An ex-refinery price set below the equivalent cost of imports, for example, constitutes a subsidy, albeit a hidden one. LP Gas distributors may, in some cases, benefit from grants, soft loans, tax credits and relief or accelerated depreciation allowances. These measures have the effect of lowering the cost of supply of LP Gas and possibly its retail price.

In practice, sales taxes or duties may offset to some degree the impact of subsidies. This is the case in Senegal, for example, where value-added tax amounts to about a quarter of the direct subsidy of around US$200/tonne on sales of 6-kilogramme cylinders. Since all fuels are subject to VAT, LP Gas still enjoys a competitive advantage equivalent to the size of the subsidy.

The effect of subsidies on demand also depends on whether competing fuels are also subsidised and, if so, by how much. If other fuels such as kerosene or charcoal are subsidised as much or more than LP Gas, demand for the latter may be lower than if no fuel were subsidised, such as in Indonesia.

The Effectiveness of LP Gas Subsidy Programmes

How effective a particular subsidy programme is judged to be in practice depends on the objectives of the programme and its costs. In principle, since a subsidy by it very nature involves a market distortion, it can only be justified if the gain in social welfare and environmental improvement is judged to exceed the net economic cost of that distortion.

LP Gas subsidies have been effective in several countries in speeding up the transition from traditional fuels, bringing real social, environmental and economic benefits to millions of households. The major shift to LP Gas and kerosene during the 1980s and 1990s in India, for example, was brought about by large subsidies. This transition has produced real improvements in indoor and urban air quality and relieved the pressure on deforestation in areas close to major urban centres[39].

Subsidy programmes may involve significant costs too:

- To the extent that they reduce the prices received by producers, subsidies undermine energy providers' return on investment and their ability and incentive to invest in new infrastructure. They can also encourage reliance on lower cost, less modern technology.
- By lowering end-use prices, subsidies reduce incentives to conserve or use energy more efficiently.
- Subsidies to producers, by cushioning them from competitive market pressures, reduce incentives to minimise operating costs, resulting in less efficient plant operation and sub-optimal investment.
- Direct subsidies in the form of grants or tax rebates and exemptions can be a drain on government finances.
- Price caps or ceilings below market-clearing levels may lead to physical shortages and a need for administratively costly rationing arrangements. This has been well demonstrated in India, where supplies of subsidised LP Gas have been restricted to urban areas to limit the overall cost of the programme.
- Subsidies can encourage cross-border smuggling, as in several African countries. Large numbers of subsidised small cylinders in Senegal are sold illegally in neighbouring Guinea, where prices are higher.
- Subsidies on small cylinders aimed at poor households may be diverted to transport or industrial uses, where the price differential is large. In India and Thailand, for example, a growing number of vehicles have been converted to use subsidised LP Gas in cylinders designed for household use - an extremely dangerous practice.

These costs are ultimately borne at least in part by the intended beneficiaries of the subsidies in addition to the rest of society. The social and environmental effects of subsidising LP Gas, like the economic impact, depend on the size and mechanism of the subsidy. Subsidies aimed at improving the welfare of poor or disadvantaged people can often lead to the opposite outcome.

[39] *ESMAP (1999).*

In practice, LP Gas subsidies that are intended to boost poor households' purchasing power or rural communities' access to modern energy may in fact be distributionally regressive. Their benefits often accrue mainly to urban middle and higher income groups, who would use the fuel even without subsidy, while their costs fall on most of the population, including the poor[40]. There are several reasons for this:

- The poorest households may be unable to afford even subsidised LP Gas or may have no physical access to it if they are located in isolated rural areas (the problem of exclusion). This is the case in rural India.
- Even if the poor are able to benefit from an energy subsidy, the financial value to them may be very small since their consumption is generally modest. Higher income households tend to benefit much more in nominal terms since they consume more of the subsidised fuel (the problem of inclusion). However, increased use of LP Gas by the rich can free up supplies of kerosene, if rationed, for poor households.
- Consumption subsidies that involve the imposition of caps on prices below market-clearing levels may lead to a need for rationing. Experience in many countries shows that in such cases middle and higher income households tend to appropriate the bulk of the available subsidised supplies, often through corruption. Price caps have also encouraged smuggling in some countries.

The environmental effects of introducing and maintaining LP Gas subsidies are complex.

The environmental effects of introducing and maintaining LP Gas subsidies are complex. If a subsidy leads to wasteful use of the fuel, the environmental impact may be negative. But where the increased use of LP Gas forms part of a shift away from traditional fuels, it can reduce deforestation and improve air quality. This is a major justification for maintaining subsidies for modern fuels in some developing countries.

Designing and Reforming Subsidies

Energy subsidies have received a bad press in recent years because of the problems described above. But not all energy subsidies are bad. A good subsidy is one that enhances access to modern energy for the poor while sustaining incentives for efficient distribution and consumption and reducing adverse environmental effects. Subsidies must therefore be assessed on a case-by-case basis. The criteria for assessment include their relative efficacy, efficiency and cost-effectiveness[41]:

- ***Efficacious*** or targeted means the subsidy reaches those for whom it is intended, namely the poor (minimising problems of inclusion and exclusion).
- ***Sector efficient*** means that the subsidy mechanism is designed in such a way as to encourage the provision of service at least cost. This is a particular concern in promoting the supply of modern fuels in rural areas.
- ***Cost-effective*** means that the subsidy achieves social goals at the lowest financial cost to the government, while providing incentives to businesses to serve poor and rural communities.

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[40] IEA/UNEP (2001)
[41] World Bank (2000a), p65.

In designing or reforming subsidies to improve poor households' access to modern fuels, policymakers need to address the following issues:

- ***Whom to subsidise:*** In general, subsidies should be aimed at rural households and the urban poor who would otherwise not use modern fuels. There is little justification for subsidising fuels for rich urban households since they can afford to pay for them.

There is a strong case for focusing subsidies on the initial cost of the cylinder deposit and appliances.

- ***What to subsidise:*** There is a strong case for focusing subsidies on the initial cost of the cylinder deposit and appliances rather than just the fuel itself. This has the virtue of promoting access to LP Gas without reducing incentives to use the fuel efficiently. With this approach, subsidies are limited to the targeted group since those already using LP Gas do not benefit. The Government can also offer incentives to distributors and cylinder manufacturers to market smaller cylinders.
- ***How to subsidise:*** The choice of instrument or mechanism has a big effect on the efficiency and efficacy of a subsidy in improving the welfare of the poor. Each has strengths and weaknesses. In general, demand-side subsidies - that is, subsidies provided directly to consumers - are more targeted than fuel or supply-side subsidies and provide stronger incentives to expand service. Demand-side LP Gas subsidies include partial payment of bills for the fuel, the cylinder or the appliances. In practice, however, this type of subsidy mechanism requires a lot of administration to identify and verify the targeted recipients and effect payment, which adds to the financial cost. Supply-side subsidies, such as direct payments to fuel distributors or cylinder manufacturers, are less costly to administer but are less targeted, since middle- and high-income households may benefit most from any lowering of retail or expansion of service. They also tend to involve much larger financial transfers, especially if they are successful in boosting fuel use.
- ***How much to subsidise:*** The size of subsidies affects both demand for the fuel and their financial and economic cost. Large LP Gas subsidies usually encourage rapid switching but can impose a major burden on government finances and the country's balance of payments. The appropriate amount of subsidy depends on national circumstances, including the seriousness of environmental and health problems, the incomes of poor households and the state of government finances. In principle, subsidies should be pitched at a level that helps the poorest households without undermining incentives to expand service and the economic health of the country. This requires a careful assessment of households' willingness to pay and projected demand, based on market and consumer surveys.

Table 11 assesses the main types of LP Gas subsidy mechanisms according to the criteria of efficacy, sector efficiency and cost-effectiveness. In general, subsidising the acquisition of the cylinder is the only mechanism that arguably meets all three requirements. But that subsidy may not be sufficient to encourage a large shift in household energy use to LP Gas. In that case, a direct subsidy on the fuel itself to small users may be justified. This could be provided on the basis of cylinder size, although there is a danger that higher-income households may profit most if they switch to using smaller subsidised cylinders. In extreme cases, subsidised LP Gas may be diverted to industrial or transport uses. To avoid these problems, the fuel subsidy could be restricted to poor households by means of vouchers or allowances for small quantities of fuel. The administrative cost would be higher, but the overall financial transfers from the government to households would be lower if the programme were run efficiently and corruption were kept to a minimum.

Table 11: Assessment of Alternative LPGas Subsidy Mechanisms for the Poor

Subsidy mechanism \ assessment criteria	*Promotes sector efficiency*	*Efficacious*	*Cost-effective*
Demand-side			
Subsidy on cylinder acquisition	✓	✓	✓
Credit for cylinder acquisition	✓	✓	
Subsidy to small users (small cylinders)		✓	✓
Subsidy to all users			
Supply-side			
Subsidy to bulk distributors			✓
Subsidy on operating costs of all distributors			✓
Investment subsidy			✓
Financing subsidy			✓

Note: A tick indicates that the mechanism meets the criterion.
Source: Adapted from World Bank (2000a), p65.

The need for a subsidy to LP Gas is greatest when the use of the fuel by poor households is still very low due to the higher initial costs of using LP Gas. Once use of the fuel is widespread, there may be a case for reducing subsidies for as long as this does not greatly undermine the fuel's competitiveness and cause a shift back to traditional fuels.

In practice, however, it can be very hard to reduce subsidies in the face of hostility from its principal beneficiaries - even when its net benefits are no longer judged to be positive. The benefits of a subsidy always accrue disproportionately to certain segments of the population. Those beneficiaries will always have a stronger interest in defending that subsidy than the rest of society, who bear the net cost of the subsidy. This phenomenon creates asymmetric incentives for politicians: it is much easier to garner political support for the interests of small, homogeneous groups that benefit from subsidies than for the comparatively vague and less tangible interest of the general population. This problem is very evident in India, where attempts to reduce energy subsidies - including those on LP Gas - have been strongly resisted by some social groups and politicians.

One way of addressing this problem is to incorporate a strict limit on the duration of the subsidy - *a sunset clause* - when the programme is initially designed. In that case, end-users are able to anticipate the reduction or removal of the subsidy and, therefore, tend to be less resistant. Where such a clause is not already in place, reforms need to be implemented in a gradual, programmed fashion to alleviate the financial pain of those who stand to lose and give them time to adjust their energy consumption patterns. The phased reduction or removal of subsidies might also need to be accompanied by compensating measures that support real household incomes in more direct ways. In any event, effective communication of the overall benefits of reform to the economy and society is essential to counter political inertia and opposition.

7.4 MICRO-CREDIT FINANCING

Another way that governments can help encourage switching to LP Gas is to promote the establishment of micro-credit or micro-finance schemes. Micro-credit agencies, usually owned by the state or by a co-operative, lend very small sums of money - often tens of dollars - to poor households or small businesses to cover the initial cost of switching. In some instances, they also lend to local entrepreneurs to set up small, local LP Gas retail outlets. Most commercial banks are reluctant to lend to the poor because of the lack of collateral, which increases risk, and high transaction costs, which keeps returns low.

The most successful micro-credit programmes are those that direct loans at income-producing activities.

Various micro-credit agencies have been set up in developing countries to extend credit to households and small enterprises. Some are proving successful in expanding energy services to the poor, including the use of LP Gas. There are around 7 000 such bodies with 13 million clients. Total outstanding loans are estimated at about US$7 billion and is growing very rapidly. Many agencies are modelled on the Grameen Bank of Bangladesh, one of the first to be established and one of the most successful (Box 8). Other successes include the Banco Solidario in Bolivia and the Rural Enterprise Programme in Kenya. The most successful micro-credit programmes are those that direct loans at income-producing activities, since the prospects of the loan being repaid are much better.

Governments, international development organisations, non-governmental organisations and donor countries can assist the development of micro-credit financing by providing the capital and expertise to set up agencies. At present, most support comes from donor countries and international organisations, such as the World Bank and United Nations bodies. Financial assistance may take the form of loans or grants. Increasing emphasis is being given to capacity building and strengthening of institutions, training and information dissemination to spread best practices.

Box 8: *Grameen Bank of Bangladesh*

The Grameen Bank of Bangladesh, set up as a non-profit organisation in 1976, is perhaps the best-known micro-credit agency. It has more than 1 000 branches throughout the country and 2 million clients, mostly women. Cumulative lending is over US$2 billion. Loans are only made to groups of at least five individuals, which reduces the risk of default. Lending rules are very simple: loans must be repaid in weekly instalments over one year; interest of 20% is charged once at the end of the year. Recovery rates are over 95%.

The Bank lends money for energy projects through a subsidiary, Grameen Shakti, which was set up in 1996. Initially, it focused on loans to rural households without electricity for the purchase and installation of photovoltaic systems. It is now expanding its activities to promote the development of other rural energy supplies, including wind power and biogas.

8 CASE STUDIES OF LP GAS USE IN DEVELOPING COUNTRIES

All three case studies demonstrate the importance of coherent, well-designed programmes for successful market development.

This Section sets out three case studies of LP Gas market development: Brazil, West Africa and India. The choice of case studies is intended to illustrate the critical success factors behind policies to promote LP Gas use and to draw out lessons for other countries. Brazil and India provide examples of the role that LP Gas can play in the successful transition to modern fuels as well as the practical problems associated with government programmes. West Africa provides a contrasting picture, with under-developed markets in some countries, despite abundant regional supplies, and rapid market development in others, especially Senegal, driven by strong government support. All three case studies demonstrate the importance of coherent, well-designed programmes for successful market development.

8.1 BRAZIL

Brazil has experienced steady growth in household consumption of LP Gas in the last two decades, thanks to rising household incomes and government pricing and subsidy policies aimed at promoting switching away from traditional fuels. Subsidies are now being phased out as part of broader policy of liberalising the oil sector. Despite this move and the increasing availability of natural gas in parts of the country, demand for LP Gas is expected to continue to grow, as per capita consumption is still fairly low relative to average incomes by international standards.

Supply and Demand Trends

Between 1995 and 1999, Brazil produced around 3.7 million tonnes per year of butane and propane (Table 12). Around 90% came from 13 refineries, mostly situated in the south, and the rest from natural gas processing plants. A number of refinery expansions and new processing facilities are expected to boost production by around 2 million tonnes per year by 2003.

LP Gas consumption has increased steadily since the 1980s. It grew at an average rate of 4.5% from 1995 to 1999, outstripping GDP growth. With indigenous production flat over that period, rising demand has been met by imports. In 1999, net imports reached a record 2.96 million tonnes, representing roughly 5% of world trade. Imports should fall sharply in the near-term as new production capacity comes on stream, but petrochemical demand is expected to lead to a revival in imports after 2004.

Table 12: Brazil LPGas Production and Demand (thousand tonnes)

	1980	1990	1995	1998	1999
Indigenous production	2 399	3 117	3 415	3 285	3 679
Imports	128	1 292	2 340	2 776	2 958
Exports	31	5	0	-3	3
Stock change	-203	-30	-21	55	-55
Total supply	2 293	4 374	5 734	6 113	6 579
Final consumption	2 693	5 080	5 802	6 589	6 862
Residential	*2 414*	*4 470*	*5 276*	*5 587*	*5 683*
Industry	*174*	*145*	*360*	*673*	*722*
Other	*105*	*465*	*490*	*329*	*457*

Source: Ministry of Mines and Energy (2000)

Market Characteristics

Petrobrás, the state-owned national oil and gas company, has a monopoly over production, imports and bulk sales of LP Gas to distributors. The company's de jure monopoly rights over these activities were lifted in 2000, but price subsidies on wholesale LP Gas mean that it is not economic for competitors to import their own supplies. There are 16 distributors, 128 filling plants and 26 000 retailers. A number of international oil companies, including Shell and ENI, have entered the market since deregulation began in the mid-1990s. Today, ENI/Agip is the largest distributor, with 22% of total sales, followed by Nacional Gas (19%), Ultragaz and SHV (both with 18%).

The residential sector makes up about 83% of the total LP Gas market in Brazil. Industrial uses account for most of the rest, with small but growing consumption in the commercial sector (including agriculture). Autogas use is illegal. Half of the country's LP Gas consumption is in the southeast, where the major cities are located.

Most households in Brazil use either LP Gas or, where available, natural gas. There are approximately 35 million households currently using LP Gas, mainly in 13-kilogramme cylinders. Less than 4% of households, mostly located in remote western or northern areas, use only traditional fuels or kerosene. Despite widespread household use of LP Gas, per capita residential consumption, at around 34 kilogrammes per year, is not especially high compared to other developing countries with similar median household-income levels. This is largely due to the relatively high rates of electrification, extensive use of electricity for water heating and cooking in microwave ovens and the warm climate.

There are an estimated 92 million branded 13-kilogramme cylinders in circulation in Brazil, equivalent to almost three per household. Until recently, distributors were allowed to collect and use other companies' cylinders. This practice undermined safety and led to accidents[42]. Under-filling of cylinders and other poor commercial practices had also become widespread by the mid-1990s. In response to these problems, the LP Gas

[42] *According to press reports, there were 3 600 LP Gas accidents in Sao Paolo and 1 184 accidents in Rio de Janeiro in 1996.*

industry in partnership with the Government introduced in 1996 a self-governing code of practice to improve the quality of service, safety and the image of LP Gas. As a result, cross-filling of cylinders has been virtually eliminated, 23 million cylinders have been re-qualified, 6 million have been scrapped and 19 million new cylinders have been introduced. The number of accidents directly related to LP Gas use has been reduced by 70%.

Industrial consumption of LP Gas is small, but growing. Until 1992, bulk supplies to industry were prohibited where alternative fuels were available. This policy was designed to maximise supply to the household sector. Many factories in the south have been switching to LP Gas as an interim measure in anticipation of natural gas becoming available.

The natural gas distribution network, supplied with gas from Bolivia, is expanding rapidly. This is starting to undermine demand for LP Gas in both the industrial and household sectors in the south. Nonetheless, demand in the country as a whole is expected to continue to grow steadily thanks to strong growth in demand in both sectors in other parts of the country and rising demand in new markets, such as autogas (if the law forbidding its use is changed). Prospects for LP Gas use are brightest in the centre of the country and the north, where per capita consumption is very low and households rely heavily on traditional fuels. Datamonitor projects average demand growth of 2.5% from 2001 to 2009, not including petrochemical feedstock demand[43]. New propylene plants are due to be commissioned by 2004, which will absorb around 500 000 tonnes/year.

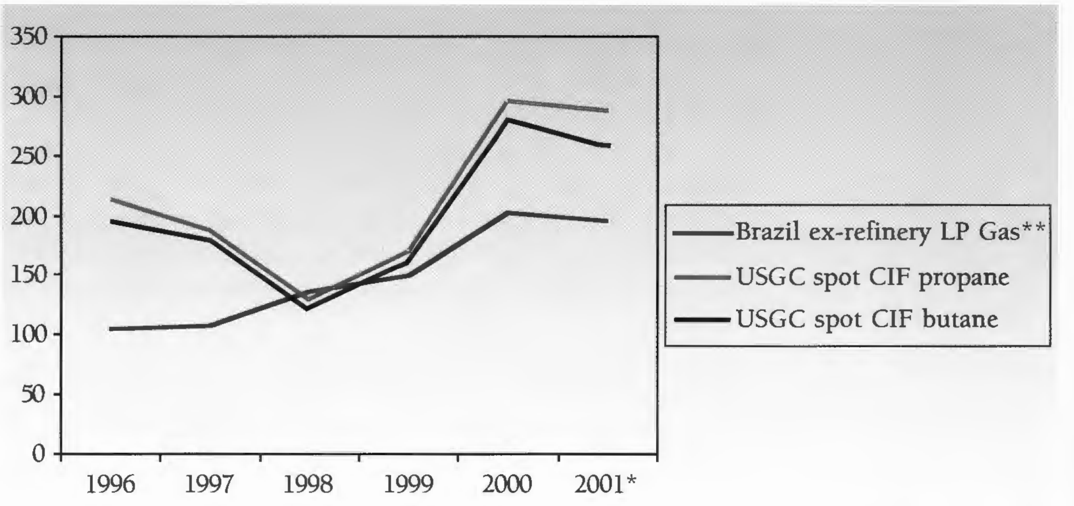
LP Gas Pricing and Subsidies

The Federal Government subsidises LP Gas through its control over wholesale prices. Although retail prices are now fully deregulated, the Government still sets the wholesale price at which Petrobrás sells LP Gas from its refineries, processing plants and import terminals. Retail prices were deregulated progressively from 1998 and the last remaining controls on retail prices in the north and northeast were lifted in May 2001.

The subsidy to wholesale LP Gas sales is effectively a cross-subsidy. Above-market prices for other oil products, primarily gasoline, are supposed to compensate Petrobrás for losses on its LP Gas sales. The Government is obliged to make good any net differences between actual revenues and the revenues that it would make if all prices were set in line with international markets. The Government's deficit on its petroleum account with Petrobrás has been growing since 1999, as wholesale product prices have not kept pace with international prices. In the first half of 2001, refinery-gate LP Gas prices were just under around US$200/tonne, over 25% below the average of US Gulf Coast spot propane and butane prices (Figure 20).

[43] *Datamonitor (2000).*

Figure 20: Brazil Wholesale LPGas Prices Compared with US Spot Prices, 1996-2001 (US$/tonne)*



** Average of 1st half 2001.*
*** Approximately a 50% propane/50% butane mix.*
Source: ANP, WLPGA (2001c).

All oil product prices should have been completely deregulated by 2001, but political disagreements have delayed the process. Wholesale price controls are now planned to be completely lifted in January 2002, although there are calls for retail-price controls to be re-introduced in the north for fear that wholesale price deregulation will result in much retail higher prices and encourage a shift back to traditional fuels there.

Once wholesale prices are deregulated, LP Gas distributors are expected to take advantage of the freeing-up of imports and new regulations that mandate third-party access to Petrobrás import terminals and pipelines. The National Petroleum Agency, ANP, is tasked with regulating access. Petrobrás, however, retains priority access to 65% of the country's import capacity.

Lessons Learned

Subsidies have played a significant part in encouraging LP Gas use in Brazil, especially in the household sector. LP Gas has largely replaced kerosene in cities and towns, and woodfuel and kerosene in rural areas. Increased LP Gas use has resulted in significant improvements in health and safety, and has reduced deforestation in many parts of the country.

The programme, however, has not been problem-free. The regulatory regime and the lack of enforcement of regulations has undermined competition and discouraged investment in LP Gas distribution for many years. Subsidies have distorted oil markets and burdened public finances.

The Government recognises that the case for subsidies is weaker than in the past, since LP Gas penetration of the residential sector is now very high. The planned removal of subsidies will probably not have much impact on fuel use, since most households already using it are unlikely to switch back to either kerosene, charcoal or wood. However, *Price deregulation and the opening up of the LP Gas market to competition should stimulate further growth of the market and attract more foreign investment.*

there is a danger that higher prices following full price deregulation will encourage poorer households to switch back to using wood in rural areas, especially the north.

Price deregulation and the opening up of the LP Gas market to competition should stimulate further growth of the market and attract more foreign investment. How rapidly this occurs will depend to some extent on how effectively the ANP regulates third-party access to Petrobrás' import terminals and pipelines.

8.2 WEST AFRICA

LP Gas markets in most countries in West Africa are in the early stages of development and consumption rates are low by international standards. However, West African LP Gas demand has expanded fairly significantly during the 1990s, making important contributions to the environment and the quality of life in several countries in the region. Demand is set to grow rapidly in the next few years.

Regional Supply and Demand

During the 1990s, LP Gas production increased rapidly in West Africa and the region has become a prolific exporter. Several new large LP Gas recovery projects in West Africa are underway or planned and supplies in the region are expected to continue to rise rapidly over the next five to ten years. This build-up in supply is large enough to support the simultaneous expansion of regional LP Gas markets and significantly higher export sales (Table 13).

Table 13: West Africa LP Gas Production and Demand (thousand tonnes)

	1995	1998	2000	2002	2005
Total Production	421	1 282	2 313	2 774	5 348
Nigeria	169	620	1 647	2 106	4 449
Congo	4	404	404	404	404
Angola	184	190	191	191	422
Others*	64	68	71	73	73
Total Demand	247	336	381	422	516
Exportable surplus	174	945	1 932	2 352	4 832

** Benin, Burkina Faso, Central African Republic, Chad, Democratic Republic of Congo, Guinea, Gambia, Guinea-Bissau, Liberia, Mali, Niger and Togo.*
Source: WLPGA/World Bank (2001).

The total regional LP Gas surplus is now around 1.9 million tonnes per year and is expected to continue to rise in the short to medium term. Even allowing for continued growth in consumption in West Africa, the regional supply surplus is expected to more than double over the next five years. These trends provide an opportunity to reduce the landed cost of LP Gas to importing countries in the region.

LPGas production has increased quickest in Nigeria since 1995, reaching more than 1.6 million tonnes in 2000. Nigeria now accounts for about 85% of total LPGas production in West Africa. The Congo is now the second largest producer and has assumed a very important role in supplying small butane cargoes to regional markets. Angola is the third largest producer, and its LPGas production is expected to expand significantly as projects to reduce gas flaring in Angola are implemented.

Market Characteristics and Trends

Private and public companies are involved to varying degrees in LPGas supply, distribution, and marketing. In countries with a local refinery, the refinery is normally responsible for imports as well as domestic supplies. Most LPGas is distributed and marketed by private oil marketing companies in the region, but government-owned companies are active in LPGas marketing in some countries. The government generally controls prices, at least at the ex-refinery level. Distribution and marketing margins are typically either controlled or heavily influenced by the authorities.

The size of the LPGas market and the average consumption per capita in West Africa have been fairly modest historically. This is still the case for the region as a whole, but there has been significant growth in consumption in a few countries in the region during the 1990s. Total LPGas sales in West Africa are currently estimated to be about 361 000 tonnes per year (Table 14).

Table 14: West Africa LP Gas Consumption, 1999

Country	*LP Gas consumption (thousand tonnes)*	*Residential/commercial*		*Population (million)*	*Res./comm. consumption per capita (Kg)*
		Thousand tonnes	*% of total consumption*		
Angola	50	45	90	11.7	3.8
Cameroon	28	27	95	14.9	1.8
Congo, Democratic Republic	1	1	90	49.6	Neg.
Congo	4	4	90	2.7	1.3
Gabon	17	15	90	1.2	12.8
Ghana	40	34	85	19.2	1.8
Cote d'Ivoire	50	43	85	15.7	2.7
Ghana	40	34	85	19.2	1.8
Nigeria	58	23	40	125.1	0.2
Senegal	100	98	98	9.5	10.3
Others	13	12	90	65.8	0.2
Total West Africa	361	301	83	315.4	1.0

Source: WLPGA/World Bank (2001).

About 60% of current LP Gas consumption in West Africa is concentrated in four countries: Cameroon, Cote d'Ivoire, Ghana, and Senegal. The only other countries in the region with significant consumption are Angola, Gabon, and Nigeria. Most of the LP Gas is used for household cooking. Around 83% of total consumption is used in the residential and commercial sectors. In some countries, this proportion is even higher. In Senegal, it is over 98%.

A common characteristic of all the West African markets is that LP Gas consumption is highly concentrated in and near major cities.

A common characteristic of all the West African markets is that LP Gas consumption is highly concentrated in and near major cities. Average per capita consumption in the four main countries is estimated at 12.4 kilogrammes per year for the major urban centres, compared with less than 1 kilogramme per person outside of those areas. LP Gas demand in the major cities represents between 65% and 90% of total national demand. This suggests that there is a particularly large potential market for LP Gas outside the major cities. Specific programmes will probably be required to spur development of markets in outlying areas.

The average annual consumption of LP Gas in residential and commercial markets in the whole of West Africa is currently estimated at only around 1 kilogramme per capita. This is very low by developing world standards. Average per capita residential consumption of LP Gas is currently over 5 kilogrammes per year in India, 8 kilogrammes in China and 36 kilogrammes in Egypt.

LP Gas consumption in the four main West African countries grew on average by about 9.5% per year from 1990 to 1999 - a significant acceleration in growth rates compared to the previous decade. Growth rates differ markedly, however, among these countries:

- ***Ghana:*** Demand increased steadily during the first half of the 1990s, but growth has since slowed, due to the removal of a price subsidy. Autogas consumption continues to decline, but use of LP Gas as a household fuel has resumed its upward path. Total demand growth averaged 10% per year from 1990 to 1999.
- ***Cote d'Ivoire:*** Market growth has averaged 9% per year over the last decade. Demand has increased more strongly since 1995 due to the positive effects of the CFA devaluation in 1994 on the local economy and the aggressive marketing practices of a new entrant.
- ***Cameroon:*** Demand has risen by only 2.2% per year since 1990. This is mainly due to a lack of any significant government policy initiatives promoting the use of LP Gas and uncertainty over plans to reform the oil sector, which has discouraged investment.
- ***Senegal:*** The highest growth market of these countries is Senegal, where demand has risen by 13% per year since 1990. This is an important example of LP Gas market development; lessons learned in Senegal might be successfully applied in other countries in the region. Several factors explain the dramatic growth in demand:
    - LP Gas has been available at very competitive prices in small 6-kilogramme bottles since the mid-1980s, due to a large subsidy. The subsidy programme accelerated switching to LP Gas, especially among low-income households.
    - Strong demand has encouraged private companies to make sizeable investments in storage, bottling and distribution. It has also drawn new participants into the market. They have adopted aggressive marketing strategies, which has helped to stimulate further growth.

- The subsidy was maintained for a long enough period of time to allow the market to expand to its present size. The Government is now in the initial phase of a five-year programme to completely eliminate the subsidy on LP Gas sold in small bottles. While the government has generally been pleased with the success of the LP Gas programme, it wants to reduce the burden of the subsidy on the state's finances. The removal of the subsidy is expected to significantly reduce future demand growth rates and may eventually lead to a decline in LP Gas use.

Supply Costs

The cost of supplying LP Gas influences retail prices and the ability of the consumer to afford LP Gas as a household cooking fuel. It also affects the amount of subsidy needed to make LP Gas competitive with other fuels. Acquisition costs are especially important for countries that have to import all or most of their needs.

The optimisation of LP Gas supply costs in developing markets typically involves reaching a balance between potential savings achieved with larger parcel sizes, to minimise shipping costs, and the cost of providing additional storage. Freight rates fall sharply as parcel size increases, especially for very small parcels. For example, unit shipping costs in West Africa are typically a third lower for 2 000 tonne parcels compared with 1 000 tonne parcels.

The limiting factor on import parcel size in West Africa is the capacity of the storage facilities in each country. Currently, most countries import LP Gas on a 'single port discharge' basis. This requires small ship movements from the source to the importing country. In theory, the countries with small parcel sizes could reduce freight costs by combining orders and using multi-port deliveries in larger ships. But there are many practical considerations that limit these opportunities. As the markets expand and the involvement of private companies in supply acquisition increases, more opportunities for supply optimisation will probably develop.

The overall size of the local market served by import facilities determines the optimal size of storage. The larger markets in West Africa will benefit most from larger parcel sizes, as the import and storage facilities will have a higher overall utilisation rate. Senegal is a good example. Over the last few years, the average parcel size of imports has increased from around 1 000 tonnes to approximately 4 000 tonnes, with a corresponding fall in freight rates.

Pricing and Competitiveness

LP Gas prices in West Africa differ widely, mainly due to differences in government policies. The price of LP Gas is at least partially controlled in all countries, mainly through control of the ex-refinery price and through explicit price subsidies in some countries.

The ex-refinery price of LP Gas varies considerably among the four countries shown in Table 15. Cote d'Ivoire, Ghana and Senegal have been slowly moving towards import parity in their ex-refinery pricing structure over several years. The ex-refinery price in Cameroon differs the most from international import parity prices, although imports account for only about 10% of total supply there. The storage, filling and distribution margins available to marketers and dealers also vary, according to government policies and market structure. Ghana has the smallest overall margin, US$103.8/tonne, due to the fact that the marketers are involved solely in cylinder filling and not distribution. The highest distribution and filling margin is in Cameroon, at approximately US$297/tonne, which represents over 60% of the end-user price.

Table 15: West Africa LPGas Price Breakdown, 2000 (US$/tonne)

Country	Cameroon (12.5 Kg)	Ghana (14.5 Kg)	Cote d'Ivoire		Senegal	
			6 Kg	12.5 Kg	6 Kg	12.5 Kg
Ex-refinery price	150.0	264.2	235.0	235.0	306.8	306.8
Shipping costs	9.2	-	-	-	-	-
Port charges	6.0	-	2.0	2.0	-	-
Taxes and Duties	1.7	39.6	4.7	4.7	-	-
Stabilisation (tax)	-	-	-	-	-	81.8
Storage and filling margin	207.6	103.8	-	-	134.7	183.5
Distribution margin	89.0	-	268.8	218.6	52.8	30.4
Value Added Tax	-	-	-	-	44.1	49.0
Transport equalisation	29.8	-	6.4	6.4	-	-
Direct subsidy	-	-	(100.2)	-	(202.0)	-
Retail price	493.3	407.5	416.7	466.7	336.4	651.5

Source: WLPGA/World Bank (2001).

Subsidies to LP Gas are explicit in the price structure in Cote d'Ivoire and Senegal. But there are hidden subsidies in the other countries through government control of the ex-refinery price. Senegal has a large direct subsidy of US$202/tonne for 6-kilogramme cylinders, although this is partially offset by a value-added tax of US$44/tonne.

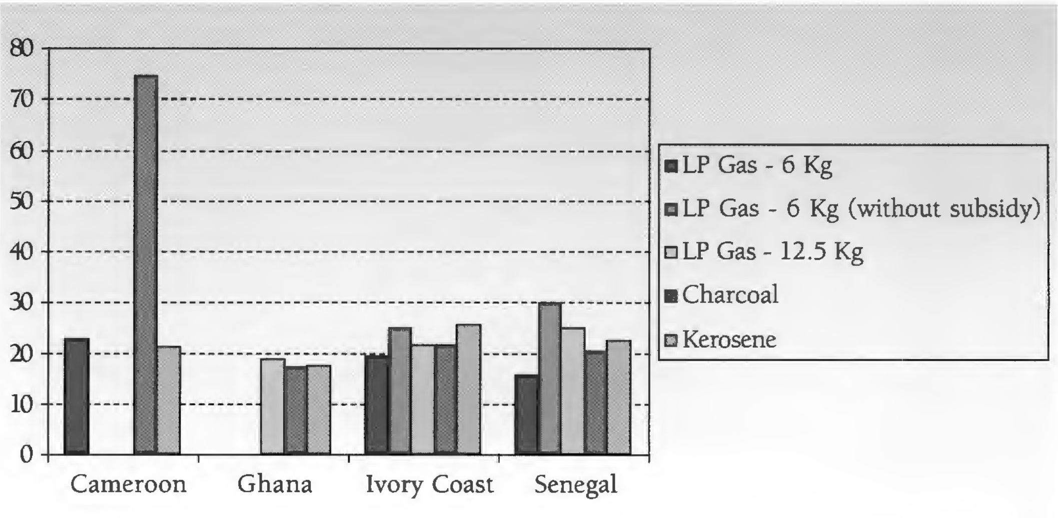
Retail LP Gas prices in the four main West African markets range from a low of US$336/tonne in Senegal in small cylinders to a high of US$652/tonne in large cylinders, also in Senegal. In markets with no explicit subsidy programme, the retail price of LP Gas ranges from US$408/tonne to US$493/tonne.

LP Gas retail prices in West Africa are not particularly high when compared to other developing markets around the world and are reasonably competitive with the prices of other household fuels (Figure 21). But LP Gas' competitive position varies from country to country and is noticeably affected by the presence or lack of subsidies:

- LP Gas has the strongest competitive position ***in Senegal*** due to the high subsidy applied to 6-kilogramme bottles. If the subsidy were removed as planned, LP Gas would no longer be the most attractive household fuel on an energy equivalent cost basis.

- ***In Ghana***, LP Gas is slightly more expensive than either charcoal or kerosene on an energy equivalent cost basis.
- ***In Cote d'Ivoire***, LP Gas has a competitive advantage versus charcoal and kerosene, even without the current subsidy.
- ***In Cameroon***, LP Gas is slightly more expensive than kerosene, but cheaper than charcoal on an energy equivalent cost basis. However, there is some doubt about the quality of the price data for charcoal given that the use of charcoal is widespread in the country.

Figure 21: Comparative Fuel Prices in Selected West African Countries (US$/GJ)



Source: WLPGA/World Bank (2001).

Initial equipment costs for LP Gas cooking appliances, a key determinant of affordability, are shown in Table 16. Total equipment costs range from a low of US$21 in Senegal to a high of US$70 in Ghana. The cost in Ghana is particularly high, because the typical consumer practice is to buy a cylinder outright rather than pay a deposit, which is the usual practice in the other countries. The standard cylinder size is also larger, 14.5 kilogrammes, in Ghana. The burner cost in Ghana is higher than the other countries because consumers in Ghana prefer to purchase a stove instead of an open burner and cooking stand.

Table 16: West Africa LPGas Equipment Costs (US$)

	Cameroon (6 Kg)	Ghana (14.5 Kg)	Cote d'Ivoire (6 Kg)	Senegal (6 Kg)
Cylinder deposit	13	32*	13	10
Burner	10	38**	10	5
Cooker stand	5	-	13	5
Total	28	70	37	21

** Cylinder purchase price. ** Stove.*
Source: WLPGA/World Bank (2001).

Key Lessons

The low level of LP Gas use in most West African countries, despite ample local supplies, is the result of a lack of proactive government action to improve its affordability and encourage its distribution, especially in rural areas. The success of the programme to encourage switching to LP Gas in Senegal serves as an example of what could achieved in other countries in the region.

Government controls over pricing and restrictions on trade and investment have held back development of the market. Liberalisation of the industry and a strengthening of the business and regulatory regime could stimulate market development and attract new market entrants. Strong participation by private industry will be essential to building an efficient distribution system. But investors need to be confident that there is a reasonable prospect of steady market growth, that stable and fair government policies and regulations are in place and that reasonable profits can be achieved.

Government incentives will probably be needed to stimulate LP Gas demand, particularly in outlying areas.

Government incentives will probably be needed to stimulate LP Gas demand, particularly in outlying areas. Consumer education and awareness programmes, to communicate the cost, convenience, safety and environmental benefits, would help to promote household use. Selective subsidies may be justified to accelerate market development, especially where deforestation is a major concern. Where subsidies are used, they should be explicit and transparent. The size and form of subsidy should take account of the price of other fuels and the likely burden on the public finances. There is a strong case in all countries for subsidising the initial cost of switching. The plan to eliminate completely LP Gas subsidies in Senegal should be re-evaluated, in view of the risk that some households could switch back to using woodfuel and charcoal.

8.3 INDIA

India is the fourth largest LP Gas market in Asia, after Japan, China and South Korea. Demand grew rapidly in the 1990s, due to switching from kerosene and traditional fuels in the residential and commercial sectors in response to heavy subsidies. But rationing of subsidised fuel has held back the development of the market. Uncertainty over government plans to remove subsidies and liberalise the downstream oil sector are discouraging investment in LP Gas distribution infrastructure and casting doubts over continued market growth. Fuel subsidies on small cylinders have been reduced greatly in recent years, but still amount to around 33% of the final price.

Supply and Demand Trends

Production of LP Gas in India grew steadily during the 1990s, mainly as a result of increased natural gas processing (Table 17). Supply from oil refineries increased sharply in financial year 1999/2000 with the commissioning of Reliance Petroleum's refinery at Jamnagar. Total indigenous supply in 2000/2001 was almost double that in 1997/1998. Oil refineries now account for 56% of total output. Refinery output should continue to increase in the near-term with new refinery expansions and greenfield projects, including the Hindustan Petroleum refinery at Bathinda, which is due on-stream by the end of 2001.

Table 17: India LPGas Production and Demand (Million tonnes)

	1991	*1995*	*1996*	*1997*	1998	1999	2000	*2001*
Indigenous production	2.150	2.858	3.253	3.148	3.460	3.854	5.336	6.610
Oil refining	*1.221*	*1.432*	*1.539*	*1.602*	*1.659*	*1.710*	*3.150*	*3.710*
Gas processing	*0.929*	*1.426*	*1.714*	*1.546*	*1.811*	*2.144*	*2.186*	*2.900*
Net imports	0.329	0.576	0.596	1.050	1.200	1.173	0.566	0.390
Consumption	2.479	3.434	3.849	4.198	4.660	5.027	5.902	6.500
Residential/commercial	*3.169*	*3.169*	*3.500*	*3.875*	*4.300*	*4.751*	*5.577*	*6.129*
Industry	*0.533*	*0.533*	*0.284*	*0.238*	*0.245*	*0.221*	*0.260*	*0.301*
Other	*0.049*	*0.049*	*0.065*	*0.085*	*0.115*	*0.054*	*0.064*	*0.070*

Note: Years refer to the financial year ending 31 March.
Source: India LPG website (www.indialpg.com); Datamonitor (2000); WLPGA (2001c); WLPGA/MCH (2000).

Consumption outpaced production during most of the last decade, growing at an average annual rate of 10.6% since 1990/1991. Almost all of this increase has come from the residential and commercial sectors.

Imports increased sharply in the mid to late 1990s, as demand outstripped indigenous production capacity. Net imports peaked at 1.2 million tonnes in 1997/1998. They fell back to less than 400 000 tonnes in 2000/2001 with the surge in refinery output. Imports currently meet only 6% of total Indian demand.

Market Characteristics

The residential and commercial sectors account for about 95% of total LP Gas use in India. LP Gas is used primarily for cooking and competes mainly with kerosene. Industry makes up for most of the rest. Autogas use is small, but is expected to grow rapidly following the lifting of a ban on its use in August 2001.

Residential and commercial LP Gas use is concentrated in urban areas and in high-income households. Urban households account for 40% of total consumption, but make up only 27% of the population. This is because incomes are higher in towns and cities and because subsidised LP Gas is only available in towns with more than 20 000 inhabitants. Even there, supply falls short of demand. There are 12 million households on the official waiting list for subsidised LP Gas, equivalent to around 1.3 million tonnes per year. A further 30 million households are unofficially waiting to be supplied. At present, an estimated 38 million households, just over a fifth of the national total, use LP Gas[44].

LP Gas is the favoured cooking fuel of middle- and high-income households. In Hyderabad, for example, LP Gas accounts for about 40% of energy use in the richest 10% of households, but only 4% in the poorest 10%[45]. This difference is due not just to the fact that LP Gas is more affordable for richer households; they also find it easier to obtain rationed, subsidised fuel through petty corruption.

Vertically integrated, state-owned companies dominate the Indian LP Gas market. The largest of them, the Indian Oil Corporation, operates seven refineries and 50 bottling plants. It supplies roughly half the residential and commercial market through a nation-wide network of 3 000 distributors. Two other public companies, Hindutsan Petroleum and Bharat Petroleum, have a 40% market share between them. Hindustan Petroleum has two refineries, an import terminal, 33 bottling plants and 1 489 tied distributors. Bharat has 28 bottling plants and 1 203 distributors.

Since 1993, private companies have been allowed to import and distribute LP Gas. Their market share has reached only about 10%, however, because they do not have access to subsidised supplies. In addition, private imports of LP Gas are subject to a special tax of 10%. There are currently around 5 600 private distributors that sell LP Gas mainly in small towns and rural areas, where subsidised fuel is not available. The largest is Shri Shakti LPG, which is based in Southern India. It has two import terminals and three bottling plants, and serves around 340 000 household customers and 12 000 commercial and industrial customers.

Price Controls and Subsidies

LP Gas and other oil products are subsidised under the Administered Price Mechanism (APM). The APM was introduced in the late 1970s and initially covered all aspects of crude oil and oil-product pricing. Box 7 outlines the way in which LP Gas prices are controlled.

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[44] *Datamonitor (2000), p 367.*
[45] *ESMAP (1999).*

Box 9: LP Gas Pricing in India

The APM is based on a retention or cost-plus formula, whereby oil companies are allowed to recover their operating costs and earn a post-tax return of 12% on net assets. The government's Oil Coordination Committee directly controls LP Gas and other oil product prices. It calculates an average ex-refinery price for LP Gas, which is applied across the country. For each distributor, a margin is calculated based on actual operating costs and a 12% return on assets. The margin is added to the ex-refinery price to give the gross selling price for each cylinder size. This price is then adjusted according to the subsidy set by the OCC to arrive at the final selling price (including an 8% excise duty set by the Government). The OCC adjusts prices and subsidies about once a year.

An Oil Industry Pool Account mechanism is used to subsidise and cross-subsidise certain oil products, by keeping their prices below international market levels and maintaining stable and uniform prices throughout the country. Financial inflows from collections of surcharges on the sale of some oil products offset outflows for meeting claims from LP Gas distribution companies for shortfalls in revenues caused by differences in allowed and actual revenues.

The Pool Account is meant to be in balance over the long run. No budgetary support is provided to the pool by the central government. In the mid-1990s, the pool fell into deficit as price adjustments failed to keep pace with changes in import prices. This led to shortfalls in disbursements to oil companies. Higher oil prices since 1999 have once again pushed the pool into deficit since the Government decided not to raise consumer prices as fast as international crude oil and product prices. Total subsidies on LP Gas were more than US$900 million in 1999/2000.

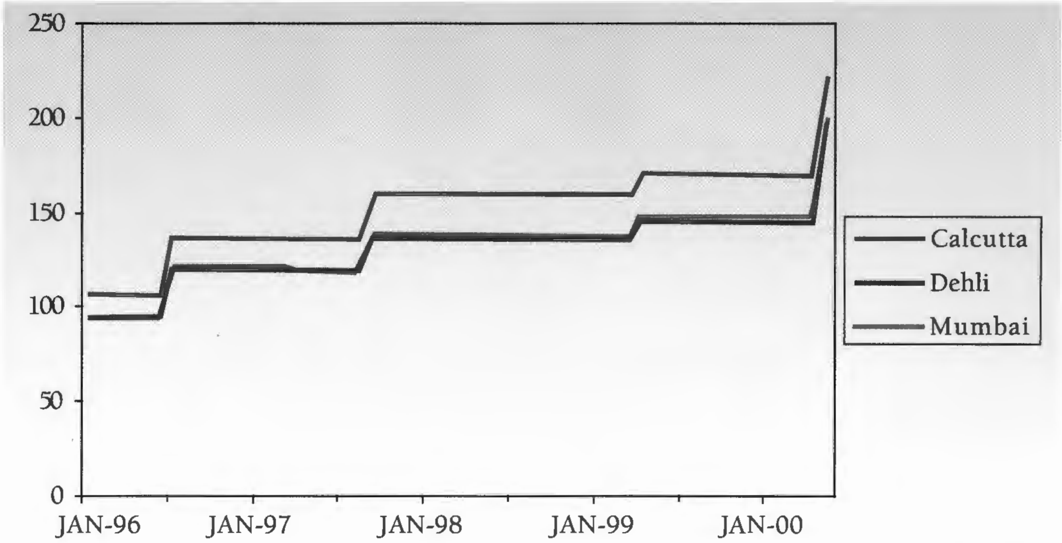
The original rationale for controlling oil prices and subsidising certain fuels was to protect the Indian economy from the destabilising effects of fluctuations in international oil markets and exchange rates. It was also intended to generate revenues for the central government and to maintain the affordability of modern energy to the most vulnerable, low-income social groups. The latter goal has become the primary justification for keeping the prices of some fuels, notably LP Gas, kerosene and diesel, below cost in recent years. Increasing local pollution problems provides a further rationale for promoting LP Gas use. Sulphur dioxide and airborne particulate concentrations in most Indian cities greatly exceed international standards, mainly due to transportation sector growth and the widespread use of coal.

Subsidies together with a centralised system of product allocation have resulted in wide distortions in energy markets.

In 1997, the Government decided to dismantle the APM and replace it with a market-based pricing mechanism. While the APM ensures a degree of price stability, it fails to provide incentives for oil companies to minimise their costs and use capital efficiently. Subsidies and cross-subsidies together with a centralised system of product allocation have resulted in wide distortions in energy markets. For example, the Government has been forced to ration the supply of subsidised LP Gas to limit the rising financial cost with increasing demand. In addition, Pool Account deficits have undermined the public distributors' ability to invest in distribution infrastructure. Private distributors, selling unsubsidised LP Gas, are reluctant to invest as they can only compete in areas not served by the public distributors and in the bulk commercial and industrial markets. Availability of both fuel and cylinders is unreliable in many parts of the country. Many households are eager to obtain a second cylinder because they experience delays in getting refills when their existing cylinder runs out.

The APM is being abolished in a phased manner. The refinery-gate prices of controlled products, including LP Gas, have been set at the level of import prices since 1998. The LP Gas subsidy was reduced from 68% to 33% at the start of 2001/2002 and is due to be reduced further to 15% at the start of 2002/2003. All prices of LP Gas and other major products will be decontrolled in 2002 and the Pool Account wound up. But the Government recently indicated that it will maintain the 15% subsidy on LP Gas and will finance it directly. Deregulation, the reduction in direct subsidies and higher international prices have led to sharp increases in LP Gas prices since 1996 (Figure 22).

Figure 22: Retail Prices of LP Gas in Indian Cities, 1996 to 2000 (rupees per 14.2 Kg cylinder)



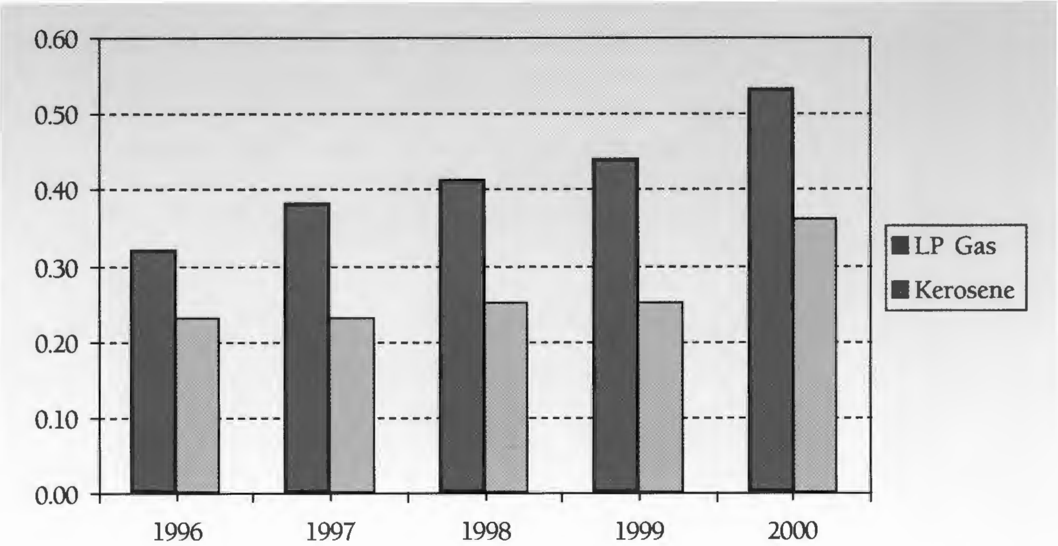
Source: TERI (2000).

The Competitiveness of LP Gas in Household Cooking

Subsidies have helped to improve the affordability of LP Gas and boost its use in the residential and commercial sectors. According to a recent IEA study, LP Gas prices in 1998 were on average 32% below what they would have been in the absence of the APM and direct subsidies[46]. However, LP Gas is subsidised less than kerosene, the most important household cooking fuel in India. The rate of kerosene subsidy was more than 50% in 1998. The larger subsidy makes kerosene much cheaper on an energy content basis than LP Gas. But the cost difference is less marked when the higher thermal efficiency of LP Gas stoves is taken into account. In 2000, kerosene was roughly one third cheaper than LP Gas used for cooking (Figure 23).

[46] *IEA/OECD (1999).*

Figure 23: Cost of LPGas and Kerosene in Calcutta, 2000 (Rupees/MJ of useful cooking energy)



Note: Costs have adjusted for cooking efficiencies: 60% for LP Gas and 35% for Kerosene.
Source: TERI (2000); Menecon Consulting analysis.

The larger subsidy on kerosene is expected to be maintained after 2002, so it will probably remain somewhat cheaper than LP Gas. Until 1991, the opposite was true[47]. Although reliable data on prices are not available, woodfuel is thought to be much more expensive than LP Gas today.

Although the initial cost of switching to LP Gas is higher than for kerosene, subsidies on cylinder deposits limit the difference for households served by public distributors. Table 18 compares equipment costs for wood, kerosene and LP Gas based on 1994 survey data for Hyderabad. Since richer households mainly use LP Gas, the subsidy on connection charges probably does not greatly affect demand. For those households, the greater convenience and practical benefits of LP Gas more than compensate for the additional initial expense of switching and the higher cost of the fuel.

Table 18: Equipment costs for Cooking Fuels, Hyderabad, 1994 (Rupees)

Cost element	LP Gas		Wood	Kerosene		
	Public sector (subsidised)	Private sector		Ordinary	Pressure	Wick
Stove	1 500 – 3 000	1 500 – 3 000	c. 50	80-90	120-150	135-150
Deposit & regulator	1 000	1 950	-	-	-	-
2nd Cylinder	108	189	-	-	-	-
Total	2 608 – 4 108	3 639 – 5 139	50	80-90	120-150	135-150

Source: ESMAP (1999).

[47] *According to a 1999 ESMAP study of household energy use in Hyderabad, LP Gas was around 20% cheaper than kerosene and 50% cheaper than wood during the 1980s on a useful energy basis. LP Gas prices overtook kerosene prices in 1992.*

Lessons Learned

India has achieved a remarkable transition from traditional to modern fuels over the last two decades. LP Gas is the second most widely used commercial fuel after kerosene. It has made a major contribution to reducing indoor and local pollution and has improved household safety and health. By reducing the use of wood, it has also helped to limit deforestation.

Rationing of LP Gas, introduced because of the high cost of maintaining subsidies, has restricted the availability of the fuel.

Subsidies have played a major role in encouraging the shift to LP Gas and kerosene. But the pricing and subsidy mechanism has led to significant distortions. Rationing of LP Gas, introduced because of the high cost of maintaining subsidies, has restricted the availability of the fuel. Private distributors are unable to compete effectively, since they do not have access to subsidised fuel. This undermines investment in the distribution network. Service in many areas is unreliable because of inefficiencies in the public distribution sector.

Deregulation, together with expanded supply from indigenous sources, should help to resolve these problems. The availability of LP Gas will increase, especially in smaller towns and rural areas. This should encourage more middle-income urban households and rich rural households to switch, despite the prospect of higher prices. Increased LP Gas use among the better off will make more kerosene, supplies of which are also rationed, available for poorer households. In determining the appropriate size of subsidy on LP Gas sales, the authorities will need to take account of the competitiveness of LP Gas against other fuels, especially kerosene, as well as the financial cost to the Central Government.

Other measures would help to promote the supply and use of LP Gas among poor and lower-middle class households:

- Any subsidies should be made available to LP Gas distributed by private companies, who could then compete on equal terms with the public distributors.
- The tax on LP Gas imports by private distributors should be removed. Any loss of revenue would be at least partly offset by a reduction in spending on fuel subsidies from the resulting switch from kerosene to LP Gas use, since the former is more heavily subsidised.
- LP Gas service could be made more affordable by lowering the initial cost of switching. This could be accomplished by:
  - making the subsidy on connection (the deposit on the cylinder and purchase of the stove) available to all potential customers;
  - incorporating the cost of connection in the monthly bill over a fixed period (perhaps one year); and
  - distributing the fuel in smaller cylinders. The Government recently announced plans to introduce 5-kilogramme cylinders onto the market to boost rural LP Gas use.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 LP GAS' CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

Finding ways to expand energy services to poor households in developing countries is one of the most pressing challenges facing the world today.

Although there are no near-term resource limits to energy supply, today's global energy system is not compatible with economic, social and environmental sustainability in the long term. A lack of access to reliable and affordable energy undermines economic development in many parts of the world. The detrimental environmental consequences of energy production and use threaten the stability of eco-systems and the health and well being of current and future generations. Moreover, modern fuels are not universally available. This inequity has important moral and political implications. Finding ways to expand energy services to poor households in developing countries, while simultaneously addressing the environmental effects of energy production and use, is one of the most pressing challenges facing the world today.

LP Gas is already playing an important role in steering both industrialised and developing countries onto more sustainable energy development paths. It contributes to strengthening the three pillars of sustainable development: the economy, by boosting productivity; social welfare, by improving living standards and enhancing safety; and the environment, by reducing indoor and outdoor pollution.

Of all the modern fuels available today, LP Gas is particularly well suited to domestic cooking and heating uses because of its clean-burning attributes and practical advantages over traditional fuels and kerosene. In particular, it is more convenient, safer and cleaner. It is also highly portable and has a high calorific value by volume and mass. Households recognise these advantages and are usually prepared to pay a premium for LP Gas over other fuels, if their incomes are high enough.

Switching from traditional fuels, coal and kerosene to LP Gas is bringing considerable health and environmental benefits at the local, regional and global levels. Indoor pollution, which mainly affects women and children, is greatly reduced. Urban air pollution and emissions of climate-destabilising greenhouse gases from LP Gas, calculated on a fuel-cycle basis, are lower than from most other fossil fuels and traditional fuels used in an unsustainable way. By reducing demand for wood and charcoal, switching to LP Gas can also reduce deforestation and can free up supplies of dung for use as a fertiliser and a soil enhancer, enhancing agricultural productivity. LP Gas is also safer than most other fuels, especially kerosene. Switching from conventional transport fuels to LP Gas (autogas) can also make a major contribution to reducing airborne emissions in both developing and developed countries.

LP Gas can play an important role in the transition to a truly sustainable global energy system.

LP Gas is a finite resource and, as a fossil fuel, is not environmentally benign. It cannot, therefore, be considered a sustainable energy source in the long term. But LP Gas can play an important role in the transition to a truly sustainable global energy system. LP Gas' comparative advantages over most other fuels mean that it can make energy development more sustainable until such time as affordable and environmentally acceptable renewable energy technologies become available. This may take several decades: fossil fuels are expected to meet most of the increase in energy demand for at least the next two to three decades.

The role of LP Gas in meeting sustainable development goals should continue to grow in the future. There is considerable potential for expanding LP Gas supply. Global output is expected to rise steadily in the coming years, thanks to increased processing of natural gas and rising oil-refinery throughputs. Production of LP Gas will probably outstrip that of most other oil products, since natural gas processing - now the largest source of LP Gas - is expanding more rapidly than crude oil processing. This is mainly because natural gas production is rising rapidly. Reduced flaring of gas will also add to the amount of gas that is processed and boosting the supply of propane and butane. Saudi Arabia and Nigeria, which flare gas the most, both plan to phase out the practice.

The residential and commercial sectors in developing countries could absorb a large proportion of this incremental supply. Economic and population growth will most likely continue to drive rapid expansion in this market segment for at least the next decade or two, particularly in urban and peri-urban areas. But the rate of growth in different countries and regions will depend on a number of factors influencing both the availability of and demand for LP Gas. Market conditions and regulatory frameworks will have to be conducive to investment in expanding distribution networks and services to the households sector, particularly in rural areas where LP Gas is not yet available. Demand is mainly driven by its competitiveness against other fuels and its affordability, in turn a function of household incomes and the price of the fuel.

Government policies and measures can strongly influence LP Gas market development. There is a good case for government support to the LP Gas sector in developing countries based on the positive contribution the fuel can make to more sustainable energy use. Active government support can catalyse LP Gas market take-off and establish a virtuous circle of growing market potential, increased investment and expanded availability.

9.2 RECOMMENDATIONS TO POLICYMAKERS

Policies to promote LP Gas use should form part of a broader policy of expanding the use of modern fuels in developing countries. Such policies should be compatible with each country's overall strategy for sustainable development and poverty alleviation. The best approach will depend on national and local circumstances. These include national policy objectives and priorities, the country's stage of economic development, market and economic conditions, the state of public finances and the institutional framework.

The conditions for developing a successful LP Gas industry are not much different to those for any other fuel. Experience has shown that the following principles can provide a practical basis for effective policies aimed at expanding modern energy services in the household sector:

- ***The provision of energy services should be competitive:*** Competition allows consumers to choose between fuels and between suppliers. It promotes service quality and drives down costs.
- ***Prices should be set by the market:*** All controls over pricing should be removed once competition is established. For as long as the state retains control over pricing, it should adopt import-parity pricing.

- ***Taxes should not undermine consumption nor distort the market inadvertently:*** Any differentials in tax rates between different household fuels should be justified by legitimate social or environmental arguments. Given the benefits of LP Gas over traditional fuels and kerosene, taxes on LP Gas should be kept to a minimum so as not to harm its competitiveness and discourage its use.

Subsidies should be aimed at rural households and the urban poor who would otherwise not use modern fuels.

- ***Subsidies should be targeted, transparent, practical and temporary:*** Where justified, subsidies should be aimed at rural households and the urban poor who would otherwise not use modern fuels. Subsidy programmes should not be unduly costly, taking account of the resources required to administer them and to monitor, prevent and deal with abuse. The financial costs and the channels through which cash payments are made must be fully transparent. On-budget costs should be properly accounted for and the results made available to the public. Subsidies should normally be regarded as a temporary measure to support switching from traditional fuels and should not be kept in place indefinitely.
- ***Barriers to market entry should be removed:*** Laws and regulations that impede trade and investment, including restrictions on repatriation of profits, should be removed. State-owned enterprises should compete on an equal footing with private companies. Privatisation or private-public partnerships should be considered as a way of attracting private capital.
- ***Barriers to switching to modern fuels should be addressed:*** Emphasis should be given to subsidising the initial cost of service, where this is a barrier to fuel switching. Subsidies can be used to lower the cost of the cylinder deposit and stove. Support should also be given to micro-credit organisations that help consumers overcome such barriers. At a minimum, financing and banking laws should not erect unnecessary barriers to the development of micro-credit financing arrangements targeted at the poor.
- ***Awareness about comparative fuel costs and attributes should be promoted:*** Governments should disseminate information and raise awareness among households about the costs and practical benefits of modern fuels compared with traditional fuels.

In promoting LP Gas use, governments must give over-riding attention to safety aspects. Governments are responsible for establishing a clear regulatory framework for the safe handling of LP Gas throughout the supply chain. It is essential that the public authorities, in partnership with the LP Gas industry, lay down and enforce appropriate harmonised operating standards for LP Gas distribution and cylinder handling. Poor safety practices undermine consumer confidence and market development.

The single most important measure to making autogas an attractive fuel to vehicle owners is to ensure that pump prices are competitive with conventional fuels.

Policies and measures to promote autogas use, both in developed and developing countries, need to take account of the barriers to switching. Experience has clearly shown that the single most important measure to making autogas an attractive fuel to vehicle owners is to ensure that pump prices are competitive with conventional fuels through lower taxes or tax exemptions. This approach usually needs to be backed up by complementary policy initiatives, including other fiscal and financial measures and non-financial regulatory initiatives. Whatever the approach adopted, a strong long-term policy commitment is crucial to give end users, fuel providers and vehicle manufacturers confidence that the development of the autogas market is sustainable.

End users need to be sure that the savings in running costs will ultimately pay back their initial investment in converting their vehicles. This in turn will encourage vehicle manufacturers to develop and market higher performance dedicated vehicles and fuel providers to make the necessary investments in the distribution infrastructure.

Putting these principles into practice should involve a partnership between government and other stakeholders, including the LP Gas industry, local communities and consumer representatives. Governments may also need to work with regional bodies to exploit potential economies of scale in importing and distributing LP Gas.

APPENDIX A

GLOBAL LP GAS MARKET STATISTICS

Summary data on LP Gas markets are shown in the following tables. More detailed statistics covering additional countries are available in the annual WLPGA publication, *Statistical Review of Global LP Gas.*

Table A-1: LP Gas Production, 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	38420	40350	41800	43320	43741	45575	46135	46811	46238	46974	48276
Canada	7910	8625	9515	9420	10100	10430	11085	11445	11660	11705	11920
North America	**46330**	**48975**	**51315**	**52740**	**53841**	**56005**	**57220**	**58256**	**57898**	**58679**	**60196**
Argentina	1451	1498	1521	1634	1899	1851	1956	2060	2205	2411	2590
Brazil	3873	3650	3871	4059	4071	3850	3730	3693	3750	4024	4359
Mexico	7610	7843	7661	7159	7620	7764	7651	6690	7085	7344	7172
Venezuela	2937	3096	3213	4144	4393	4657	4866	4900	5598	5309	5440
Other	2146	2221	2430	2554	2589	2679	2887	2764	2804	2938	3135
Latin America	**18017**	**18308**	**18696**	**19550**	**20572**	**20801**	**21090**	**20107**	**21442**	**22026**	**22696**
France	2189	2216	2147	2478	2232	2342	2633	2839	2815	2999	3382
Germany	2074	2200	2391	2587	3076	2965	2774	2574	2523	2501	2958
Italy	2187	2215	2326	2433	2296	2245	2176	2235	2164	2354	2387
Netherlands	1980	1660	2215	1412	1287	1371	1290	1382	1537	1202	1360
Norway	2100	2250	2128	2365	3206	3774	3900	4000	3800	4100	4106
Spain	1698	1409	1739	1229	1244	1332	1175	1238	1480	1459	1371
United Kingdom	3560	3500	3900	4423	5176	5533	5851	6200	6500	6450	6490
Other	3780	3907	4006	4177	4417	4139	4515	4473	4910	4654	4831
Europe	**19568**	**19357**	**20852**	**21104**	**22934**	**23701**	**24314**	**24941**	**25729**	**25719**	**26885**
Russia	n.a.	n.a.	7165	6113	4886	5039	4717	4751	4561	5528	5760
Other	n.a.	n.a.	1009	1006	895	859	922	938	968	1081	1164
FSU	**10136**	**10000**	**8174**	**7119**	**5781**	**5898**	**5639**	**5689**	**5529**	**6609**	**6924**
Iran	1300	1700	2320	3300	3600	3710	3400	2990	3040	3213	3372
Iraq	1110	170	402	1086	1300	1300	1350	1144	1180	1200	1250
Kuwait	2410	100	1200	2671	2930	3312	3320	3324	3130	3061	2925
Qatar	814	782	1130	1175	1154	1327	1345	1350	1350	1396	1450
Saudi Arabia	13546	15253	15996	16366	17628	18010	18120	18100	17600	17668	17950
UAE	4480	4996	4760	4950	4760	4810	5125	5272	6190	6250	6307
Other	940	1060	1196	1497	1585	1770	1724	1799	1815	1804	1799
Middle East	**24600**	**24061**	**27004**	**31045**	**32957**	**34239**	**34384**	**33979**	**34305**	**34592**	**35053**
Algeria	5433	5130	5060	5000	5030	5100	5600	6700	7240	8300	9100
Egypt	904	901	1004	1143	1232	1312	1307	1339	1379	1450	1755
Nigeria	55	55	60	60	60	55	60	120	475	1083	1203
Other	1296	1366	1459	1524	1734	1881	1990	1953	2228	2199	2396
Africa	**7688**	**7452**	**7583**	**7727**	**8056**	**8348**	**8957**	**10112**	**11322**	**13032**	**14454**
Australia	2539	2539	2498	2606	2628	2536	2929	3280	3060	3130	3200
China	2056	2371	2666	2771	3093	3663	4115	5116	5805	6779	8553
India	2075	2404	2500	2681	2744	3250	3356	3450	3494	4006	6057
Indonesia	2600	2700	2785	2777	3122	2941	3227	2886	2499	2394	2214
Japan	4459	4466	4483	4197	4082	4387	4433	4623	4300	4508	4499
Malaysia	587	521	600	950	1186	1455	1499	1903	2142	2348	2485
South Korea	1030	1094	1259	1200	1263	1377	1390	1835	2451	2824	2697
Thailand	741	1000	1186	1309	1287	1620	1959	2508	2415	2706	3011
Other	1356	1407	1497	1589	1891	2143	2396	2538	2568	2854	2904
Asia/Pacific	**17443**	**18502**	**19474**	**20080**	**21296**	**23372**	**25304**	**28139**	**28734**	**31549**	**35620**
World	**143782**	**146655**	**153098**	**159365**	**165437**	**172364**	**176908**	**181223**	**184959**	**192206**	**201828**

Source: WLPGA (2001c)

Table A-2: LP Gas Availability to Local Market, 2000

	Production	Imports	Exports	Consumption
United States	48276	6245	2450	52225
Canada	11920	326	6020	5991
North America	**60196**	**6571**	**8470**	**58216**
Argentina	2590	0	976	1586
Brazil	4359	2812	35	7002
Mexico	7172	3839	173	10829
Venezuela	5440	0	1679	3761
Other	3135	2955	816	5262
Latin America	**22696**	**9606**	**3679**	**28440**
France	3382	1777	1402	3757
Germany	2958	648	760	2761
Italy	2387	1904	381	3872
Netherlands	1360	1708	1482	1586
Norway	4106	406	3400	1112
Poland	298	877	0	1175
Portugal	270	760	20	1031
Spain	1371	1224	116	2496
Turkey	670	3817	0	4483
United Kingdom	6490	331	3462	3359
Other	3593	2282	1517	4319
Europe	**26885**	**15734**	**12540**	**29951**
Russia	5760	0	980	4780
Other	1164	624	391	1397
Former Soviet Union	**6924**	**624**	**1371**	**6177**
Iran	3372	0	1175	2197
Iraq	1250	0	0	1250
Qatar	1450	0	950	500
Saudi Arabia	17950	0	12436	5415
Other	11031	598	8985	2649
Middle East	**35053**	**598**	**23546**	**12011**
Algeria	9100	0	7370	1730
Egypt	1755	900	155	2500
Morocco	266	865	0	1131
Other	3333	623	2164	1794
Africa	**14454**	**2388**	**9689**	**7155**
Australia	3200	450	1470	2260
China	8553	4817	16	13355
India	6057	606	0	6478
Japan	4499	14754	30	18950
Malaysia	2485	420	1105	1801
Phillipines	475	850	195	1135
South Korea	2697	4859	590	6765
Taiwan	850	815	193	1480
Thailand	3011	1	670	2284
Other	3793	679	2262	2208
Asia/Pacific	**35620**	**28251**	**6531**	**56716**
World	**201828**	**63772**	**65826**	**198666**

Source: WLPGA (2001c).

Table A-3: LP Gas Consumption, 1990-2000

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United States	41065	43660	45165	45750	48802	48886	51724	52108	52199	53850	52225
Canada	4530	4980	5400	5830	5480	5506	5822	6016	6135	6210	5991
North America	**45595**	**48640**	**50565**	**51580**	**54282**	**54392**	**57546**	**58124**	**58334**	**60060**	**58216**
Argentina	1018	1032	909	1226	1298	1326	1379	1433	1577	1550	1586
Brazil	5093	5059	5344	5376	5483	5806	6126	6372	6602	6876	7002
Mexico	6004	6348	7487	7696	7904	8146	8629	8823	9371	10145	10829
Venezuela	2365	2579	2181	3449	3545	3576	3145	3231	3651	3476	3761
Other	2709	2963	3143	3330	3645	3970	4303	4540	4730	4942	5262
Latin America	**17189**	**17981**	**19064**	**21077**	**21875**	**22824**	**23582**	**24399**	**25931**	**26989**	**28440**
France	2655	3014	3364	3283	3571	3646	3704	3558	3634	3773	3757
Germany	2447	2851	2893	3068	3525	3447	3368	3199	3043	2682	2761
Italy	3431	3635	3422	3588	3512	3552	3509	3563	3763	3952	3872
Netherlands	2496	2338	2528	2374	2276	2130	1883	1803	2102	1481	1586
Norway	862	870	981	989	994	1004	1103	1105	1118	1118	1112
Poland	143	142	157	212	372	557	695	845	880	1009	1175
Portugal	770	826	888	941	1001	1033	1134	1155	1079	1060	1031
Spain	2327	2470	2465	2380	2361	2294	2401	2316	2531	2570	2496
Turkey	1571	1688	1854	2069	2083	2356	2422	2883	3223	3363	4483
United Kingdom	3400	3500	3400	3500	3450	3413	3253	3292	3220	3140	3359
Other	3479	3672	3804	3795	3860	3783	4053	4242	4393	4243	4319
Europe	**23581**	**25006**	**25756**	**26199**	**27005**	**27215**	**27525**	**27961**	**28986**	**28391**	**29951**
Russia	n.a.	n.a.	6452	4409	3955	4204	3814	3686	3535	3582	4780
Other	n.a.	n.a.	1624	1405	1283	1316	1218	1251	1326	1349	1397
FSU	**8848**	**9261**	**8076**	**5814**	**5238**	**5520**	**5032**	**4937**	**4861**	**4931**	**6177**
Iran	1000	1300	1520	1700	1800	1900	1925	2010	2037	2063	2197
Iraq	1030	170	352	1016	1220	1300	1350	1144	1180	1200	1250
Saudi Arabia	1150	1171	1208	1605	2729	3116	3164	3650	3600	4100	5415
Other	1066	1124	1539	1712	1979	2173	2302	2520	2642	2911	3149
Middle East	**4246**	**3765**	**4619**	**6033**	**7728**	**8489**	**8741**	**9324**	**9459**	**10274**	**12011**
Algeria	1144	1800	1400	1400	1549	1500	1406	1410	1420	1600	1730
Egypt	933	921	988	1147	1234	1338	1540	1758	1963	2430	2500
Morocco	521	586	709	768	852	902	904	940	1036	1066	1131
Other	1048	1128	1190	1313	1502	1442	1558	1582	1643	1715	1794
Africa	**3646**	**4435**	**4287**	**4628**	**5137**	**5182**	**5408**	**5690**	**6062**	**6811**	**7155**
Australia	1501	1635	1728	1879	1984	2037	2078	2085	2175	2230	2260
China	2142	2544	2975	3441	4450	5906	7328	8347	10069	12245	13355
India	2425	2624	2760	3031	3308	3950	4198	4610	4878	5660	6478
Japan	18977	19331	19548	19466	18942	19273	19788	19473	18848	18976	18950
Malaysia	629	617	693	1040	1176	1270	1392	1510	1468	1723	1801
Phillipines	396	407	431	455	510	737	810	879	938	1058	1135
South Korea	3065	3702	4629	5101	5365	5543	5761	6036	5862	6552	6765
Taiwan	1272	1259	1324	1336	1367	1478	1410	1562	1498	1525	1480
Thailand	1015	1095	1259	1372	1366	1502	1829	1898	1901	1936	2284
Other	942	1163	1315	1399	1495	1755	1644	1806	1842	2002	2208
Asia/Pacific	**32364**	**34377**	**36662**	**38520**	**39963**	**43451**	**46238**	**48206**	**49479**	**53907**	**56716**
World	**135469**	**143465**	**149029**	**153851**	**161228**	**167073**	**174072**	**178641**	**183112**	**191363**	**198666**

Source: WLPGA (2001c)

Table A-4: LP Gas Consumption by Sector, 2000

	Residential	Agriculture	Industry	Transport	Refinery	Chemicals	Total
United States	12635	2738	4902	720	8031	23199	52225
Canada	1290	141	470	380	2085	1625	5991
North America	**13925**	**2879**	**5372**	**1100**	**10116**	**24824**	**58216**
Argentina	1032	0	5	0	0	499	1586
Brazil	5590	15	1397	0	0	0	7002
Mexico	8960	34	975	860	0	0	10829
Venezuela	953	0	107	11	1588	1102	3761
Other	4641	22	526	73	0	0	5262
Latin America	**21176**	**71**	**3060**	**944**	**1588**	**1601**	**28440**
France	1778	578	584	217	0	600	3757
Germany	1118	0	583	10	0	1050	2761
Italy	2323	24	111	1414	0	0	3872
Netherlands	58	28	41	570	0	889	1586
Norway	5	9	94	4	0	1000	1112
Poland	440	44	86	605	0	0	1175
Portugal	453	0	557	21	0	0	1031
Spain	2122	66	276	32	0	0	2496
Turkey	2145	17	1039	1282	0	0	4483
United Kingdom	579	123	343	19	810	1485	3359
Other	3502	72	2753	1637	0	838	8802
Europe	**12378**	**944**	**5428**	**4529**	**810**	**5862**	**29951**
Russia	1674	0	0	600	0	2506	4780
Other	1229	2	80	86	0	0	1397
FSU	**2903**	**2**	**80**	**686**	**0**	**2506**	**6177**
Iran	1986	0	0	211	0	0	2197
Iraq	1250	0	0	0	0	0	1250
Saudi Arabia	995	0	0	0	820	3600	5415
Other	2205	23	154	0	0	767	3149
Middle East	**6436**	**23**	**154**	**211**	**820**	**4367**	**12011**
Algeria	1498	0	50	182	0	0	1730
Egypt	2350	0	150	0	0	0	2500
Morocco	1051	0	80	0	0	0	1131
Other	1564	0	200	30	0	0	1794
Africa	**6463**	**0**	**480**	**212**	**0**	**0**	**7155**
Australia	776	0	0	1484	0	0	2260
China	11109	0	1921	325	0	0	13355
India	6108	0	300	0	0	70	6478
Japan	7713	0	7627	1603	0	2007	18950
Malaysia	1236	0	265	0	0	300	1801
Phillipines	990	0	145	0	0	0	1135
South Korea	2745	0	425	3025	0	570	6765
Taiwan	1090	0	280	13	0	97	1480
Thailand	1348	0	313	162	0	461	2284
Other	1665	0	442	69	0	32	2208
Asia/Pacific	**34780**	**0**	**11718**	**6681**	**0**	**3537**	**56716**
World	98061	3919	26292	14363	13334	42697	198666

Source: WLPGA (2001c).

Table A-5: Per Capita LP Gas Consumption in the Residential Sector in Selected Countries, 1999

	Population (millions)	Consumption	
		Total (thousand tonnes)	Per capita (Kg)
North America			
United States	273.0	11952	43.8
Canada	30.5	1275	41.8
Latin America			
Argentina	36.6	1020	27.9
Brazil	163.9	6123	37.4
Chile	15.0	860	57.3
Colombia	41.6	726	17.5
Dominican Republic	8.3	388	46.7
Ecuador	12.4	582	46.9
Mexico	97.4	8638	88.7
Peru	25.2	365	14.5
Venezuela	23.7	1676	70.7
Europe			
France	60.3	1854	30.7
Germany	82.1	1001	12.2
Italy	57.6	2454	42.6
Netherlands	15.8	60	3.8
Norway	4.5	4	0.9
Poland	38.7	454	11.7
Portugal	10.0	466	46.6
Turkey	65.8	2115	32.1
Spain	39.4	2061	52.3
United Kingdom	59.5	574	9.6
Former Soviet Union			
Russia	146.2	1585	10.8
Ukraine	49.9	284	5.7
Middle East			
Iran	62.7	2063	32.9
Iraq	22.8	1450	63.6
Jordan	6.5	245	37.7
Saudi Arabia	19.9	900	45.2
Syria	16.1	475	29.5
Yemen	17.7	435	24.6
Africa			
Algeria	29.9	1430	47.8
Egypt	67.2	2430	36.2
Kenya	29.6	22	0.7
Morocco	28.2	960	34.0
Senegal	9.3	96	10.3
Tunisia	9.5	313	32.9
Asia/Pacific			
Australia	19.0	770	40.5
China	1253.6	10587	8.4
India	997.5	5350	5.4
Indonesia	207.0	649	3.1
Japan	126.7	7496	59.2
Malaysia	22.7	1005	44.3
Pakistan	134.8	207	1.5
Phillipines	74.3	921	12.4
South Korea	23.4	2266	96.8
Sri Lanka	19.0	121	6.4
Taiwan	22.0	1213	55.1
Thailand	60.2	1206	20.0
Vietnam	77.5	160	2.1

Source: WLPGA/MCH (2000); IMF (2001)

APPENDIX B

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APPENDIX C

ABBREVIATIONS AND ACRONYMS

ANP	Agência Nacional Petróleo (Brazil)
APM	Administered Price Mechanism (India)
Cif	Carriage, insurance and freight
CO	Carbon monoxide
CO_2	Carbon dioxide
ESMAP	Energy Sector Management Assistance Programme
FSU	Former Soviet Union
GDP	Gross Domestic Product
GTL	Gas-to-liquids
HC	Unburned hydrocarbons
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KWh	Kilowatt-hour
Kg	Kilogramme
LPG	LP Gas or liquefied petroleum gas
MJ	Megajoule
Mtoe	Million tonnes of oil equivalent
NGL	Natural gas liquid
N_20	Nitrogen oxide
NO_x	Nitrous oxides
OECD	Organisation for Economic Co-operation and Development
OCC	Oil Coordination Committee (India)
PM	Particulate matter (soot)
PV	Photovoltaics
SO_x	Sulphur oxides
TNMOC	Total non-methane organic compounds
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VAT	Value-added tax
WEC	World Energy Council
WHO	World Health Organisation
WLPGA	World LP Gas Association

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