Africa Gas Initiative

Main Report

Volume I

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

PURPOSE

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

GOVERNANCE AND OPERATIONS

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

FUNDING

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

FURTHER INFORMATION

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

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Foreword

The Africa Gas Initiative (AGI) Study is aimed at identifying countries where gas flaring could be reduced, for better utilization in the industrial and commercial sectors of their economies. This study was conducted by Mourad Belguedj, Senior Energy Specialist and Team Leader at the Oil and Gas Division of the World Bank and Henri Beaussant, Gas Economist and consultant.

The focus of the study, aimed initially at select countries on the West Coast of Africa, is of direct relevance to ESMAP's mandate and might be useful to Policy makers, Industry and practitioners in the target countries. The Study is published as part of the ESMAP series of reports and may usefully contribute to Project Identification and to addressing key Policy Issues in these countries, as well as enriching the debate on Energy Sector Reform. The authors wish to express their gratitude to all the colleagues who contributed directly or indirectly, to the review and completion of this work.

Abbreviations and Acronyms

AGI	Africa Gas Initiative
CAPEX	Capital Expenditure
CH4	Methane (natural gas)
CIF	Cost, Insurance, Freight
CO	Carbon Monoxide
CO2	Carbon Dioxide
DME	Dimethyl-ether
DoE	Department of Energy (US)
EIA	Energy Information Administration (US DoE)
ESMAP	Energy Sector Management Assistance Program
FOB	Free on Board
FSU	Former Soviet Union
F-T	Fischer-Tropsch (GTL technology)
GDP	Gross Domestic Product
GGS	Gas Gathering System
GHG	Greenhouse Gas
GTL	Gas-to-Liquids
GTP	Gas-to-Power
HSFO	High Sulfur Fuel oil
IEA	International Energy Agency
IOC	International Oil Company
IPP	Independent Power Producer
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NGL	Natural Gas Liquids
NOC	National Oil Company
NWE	Northwest Europe (Rotterdam)
O&G	Oil and Gas
OECD	Organization of Economic and Cooperation Development
OPEX	Operating Expenditure
R&C	Residential and Commercial
RTP	Reserves to Production (ratio)
SSA	Sub Saharan Africa
UN	United Nations
US	United States
USD	US Dollar
WLPGA	World LPG Association

Units of Measure

BBBL	billion barrels
BBOE	billion barrels oil equivalent
BCF	billion cubic feet
BCM	billion cubic meters
BL, BBL	barrel, barrels
BOE	barrels oil equivalent
CF, CFD	cubic feet, cubic feet per day
GJ	gigajoule
GW, GWH	gigawatt, gigawatt-hours
KCAL	kilocalorie
KW, KWH	kilowatt, kilowatt-hour
MBOE, MMBOE	thousand, million barrels oil equivalent
MBPD	thousand barrels per day
MCAL	megacalorie
MCF	thousand cubic feet
MCFD	thousand cubic feet per day
MMB	million barrels
MBL	thousand barrels
MMBTU	million British Units
MMCFD	million cubic feet per day
MMCM	million cubic meters
MMT	million tons
MT	thousand tons
MTOE	thousand tons oil equivalent
MTY	thousand tons per year
MW, MWH	megawatt, megawatt-hour
TCF	trillion cubic feet
TJ	terajoule
TCM	trillion cubic meters
TOE	tons oil equivalent
M, K	thousand, kilo (10^3)
MM, M	million, mega (10^6)
B, B, G	billion, giga (10^9)
T, T	trillion, tera (10^12)

Conversion and Equivalences

Volume

1 cm	35..315 cf
1 mcf	28..32 cm
1 bl	159 liters ; 0.159 cm
1 cm	6.29 bbl

Energy content (LHV)	*kcal/kg*	*btu/kg*
oil equivalent	10,000	39,690
heavy fuel oil	9,750	38,690
gas oil, diesel oil	10,000	39,690
jet fuel	10,470	41,520
kerosene	10,390	41,230
LPG	11,000	43,600
fuelwood	3,000	11,940
charcoal	7,000	27,860
natural gas (per cm)	8,500	33,740

Energy Equivalences

1 kWh = 0.86 Mcal = 3.6
MJ
1 mmbtu = 252 Mcal = 293 kWh = 1,055 MJ

1,000 cm natural gas =	0.85 toe
1,000 kWh electricity =	0.11 toe (final consumption)
1 ton wood =	0.30 toe
1 ton charcoal =	0.70 toe

Rules of thumb

natural gas: 1 mcf ~ 1 mmbtu ~ 1 GJ
natural gas: 1 mmcfd ~ 10 mmcmy
oil: 1 bpd ~ 50 tpy
natural gas: USD 1/mmbtu ~ USD 1/mcf ~ USD 40/mcm

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Introduction

Objectives

1.1 The Africa Gas Initiative (AGI) has been established by the Oil and Gas Division of the World Bank to promote the utilization of natural gas in Sub Saharan Africa. Initial emphasis was put on countries along the West African coastline and the Gulf of Guinea, where most of the region's gas reserves are located, and where a significant proportion of the gas produced is currently wasted through flaring or venting.

1.2 The AGI was initiated at a conference held in Addis Ababa, Ethiopia in June 1994, hosted by the UN Economic Commission for Africa, and the World Bank. This meeting was attended by Government representatives from eighteen African countries as well as twenty one national oil corporations and private companies. The goal of the participants was clearly stated as the need:

- to put an end to gas flaring,
- to develop indigenous natural gas resources for local markets and for exports,
- to reap more economic benefits from gas substitution, reduced imports or increased exports of oil products, and
- to improve environmental conditions at both local and global levels.

1.3 It was recognized that, in order to achieve these goals, an appropriate enabling environment, based on market driven principles was required. Thus the AGI's major objective was set to focus on the development of projects as well as of technical assistance for institutional building. Possible gas projects would include gas flaring reduction by field re-injection, and gas utilization for power generation, industry, and transformation into secondary energy carriers. Another benefit of gas operation was to generate additional revenues through condensate and NGL stripping and sales.

1.4 With regard to environmental benefits, gas development would reduce sulfur and particulates emissions caused by burning polluting liquid fuels. It would decrease greenhouse gas emissions released by liquid fuels combustion and methane venting. Also, natural gas operation would increase the production of LPG by separation in the gas stream, which would in turn help mitigate the adverse consequences of deforestation by substituting LPG for charcoal and wood.

1.5 Close co-organization and co-operation between international oil companies (IOC) that operate the oil fields, national oil companies, governments and public agencies, was considered a pre-requisite to implement both projects and policies. The World Bank, with its pool of expertise and access to information and people, would facilitate the project development process by providing assistance and by playing the role of 'honest broker'. The World Bank Group is also able to mobilize and engineer financing schemes from various sources, including its own.

Resource Base

1.6 Sub-Saharan Africa holds a modest place in the world gas industry. Although oil reserves (thus, associated gas) are far from negligible, the region is not gas prone and does not shelter any of those giant gas deposits that constitute the bulk of the reserves of the Middle East, North Africa and the former Soviet Union. They are either located close to oil fields along the Atlantic seaboard, or they lie stranded across the continent, scattered along a 6,000 km-long bow that stretches from offshore Namibia to Ethiopia. Associated gas is exclusively located in the oil provinces along the Gulf of Guinea, from Angola to Cote d'Ivoire, mostly in the offshore.

1.7 Most of gas produced is associated, and the larger share of this gas is either flared or re-injected. While non-associated gas accounts for about half of gas reserves, the amount of non-associated gas to be produced and marketed remains limited. But among marketed gas, non-associated gas is prominent. In Nigeria, most of the gas consumed domestically (e.g. for power generation) is non-associated. The share of associated gas in marketed gas, however, is expected to increase as export schemes develop.

Table 1.1 – The Place of Sub-Saharan Africa in the World Gas Industry

Region	*Gas Reserves (Tcf)*	*Gas Production (Bcf)*	*Gas Marketed (Bcf)*	*Oil Reserves (mmb)*
North America	296	32.3	25.7	67
Central & South America	222	4.6	2.8	86
Western Europe	173	11.1	10.1	18
FSU and Eastern & Central Europe	2,000	26.3	26.3	59
Middle East	1,726	9.9	5.5	677
North Africa	207	6.0	2.9	43
Sub-Saharan Africa	**147**	**1.8**	**0.3**	**27**
Share of SSA (percent)	2.8	1.8	0.4	2.7
Far East & Oceania	321	9.2	8.1	42
Total World	5,087	101.1	81.7	1,020

Source: Oil & Gas Journal through US DoE. Figures are for 1998 (Gas reserves) and 1996 (Gas production and gas marketed). Figures for gas marketed include gas exports; they may include own uses.

1.8 Gas markets can be established in Africa. Gas reserves in Sub Saharan Africa are estimated to be 141 Tcf, and these resources should be developed in an efficient manner. Many countries have substantial undeveloped gas reserves. Both associated and non□associated gas can be developed from over 400 known oil and gas fields. While Nigeria remains by far the oil (and gas) giant in the region, other countries are endowed with enough resources, whether associated or not, to make gas operation economic. The AGI has focused primarily on Angola (1.7 Tcf), Cameroon (3.9 Tcf), Congo (3.2 Tcf), Cote d'Ivoire (1 Tcf), Equatorial Guinea (1.3 Tcf) and Gabon (1.2 Tcf). Within these countries, 11 fields with proven recoverable reserves of more than 400 Mcm have been identified for development.

1.9 The issues raised are being systematically approached by the AGI. The AGI is working to change the current situation and in doing so, has received precious support from many African Governments. It makes sense for all involved that such a valuable resource can be used productively. This includes substituting gas for liquid fuels, e.g. for power generation, to save economic resources by reducing fuel imports. This is the approach which is proposed and it started to show positive results wherever it has been tried.

Methodology

1.10 The methodology adopted was built on four key steps leading from study to project phase. First, a desk study was conducted within the Bank to identify the most likely candidate countries, with enough resources and potential to develop small projects. The desk study reviewed existing documents and prior field research conducted by the Bank, to identify the most likely candidate countries with enough resources and potential to develop small projects. For this purpose, AGI developed a database, which compiled information by conducting extensive review of traditional sources of data, supplemented by classic questionnaires sent to governments and operators. The AGI focused initially on areas where the potential for developing gas markets was high. This task however is known to be time consuming as data is often non existent or very approximate and requires besides close collaboration, patience, perseverance and strong commitment from all concerned.

1.11 In the second phase, field visits to countries and Governments were conducted, which were followed by discussions with oil and gas operators, including national oil companies (NOC). A review was undertaken in collaboration with local counterparts, in order to evaluate potential gas projects in greater detail. This step was made necessary as gas fields needed to be assessed, and the availability of indigenous resources determined prior to launching field development. The results of the second phase led to pre-feasibility studies for each identified gas development project.

1.12 In the third phase, subsequent to confirmation of data on reserves and markets, a Bank Mission of experts, including outside consultants where required, would undertake a feasibility study to assess and identify upstream and downstream components of a credible "project idea." Definition and conceptualization of the project idea include data analysis and determination of required gas processing facilities, as well as gas pipeline and distribution systems. Whenever the power sector is found to be a good candidate for project start-up, extensive studies of the local and regional power sector were also carried out. Economic and financial evaluations of the selected project were conducted during the feasibility study phase, using standard World Bank procedure for project viability.

1.13 Fourth, the project idea was refined into a proposal which was submitted to Government and industry at large, for review and decisions aimed at materializing and managing the project.

Presentation of Conclusions and Recommendations

1.14 Presently, identification of the gas resource base and preliminary recommendations for gas utilization have been completed for Angola, Cameroon, Congo and Gabon. Technical assistance with regard to institutional and regulatory framework have been conducted in Cameroon and Cote d'Ivoire. Also, AGI has undertaken the analysis of current petroleum fiscal legislation, to review the profitability of gas field development from the investors' viewpoint as well. This analysis has enabled the World Bank to provide recommendations to respective governments to introduce required changes in their petroleum laws. The efforts of AGI have resulted in a very comprehensive analysis, and governments are more receptive to the Bank, given its track record of impartiality in its role as "honest broker."

1.15 The current (main) report presents the global findings and conclusions of the first Phase of the AGI program. They are presented in a sectoral fashion, with emphasis on:

- Gas resources;
- Developing markets for natural gas;
- LPG, and
- Institutional and regulatory matters.

1.16 The main report is complemented by five Country Reports, which summarize the work performed during the first Phase in the following countries:

- Angola
- Cameroon
- Congo
- Gabon, and
- Cote d'Ivoire

1.17 In each Country Report, emphasis is put on the issues that appeared to be of particular importance in the relevant country, and on the projects that could be developed in order to address those issues. In particular, the potential use of gas for power generation is addressed in detail through ad hoc consultant reports prepared for all countries, except Cote d'Ivoire. For the latter, where gas-to-power projects had already been initiated at the time the AGI started activities, emphasis has been put on the need for an institutional and regulatory framework dedicated to gas downstream activities. Such work has also been conducted for Cameroon, where a project exists to develop gas for industry.

2

Gas Resources

Gas Reserves

2.1. Although no gas-oriented exploration campaigns have ever been conducted in the region, Sub Saharan Africa is known to be sitting on a sizeable amount of gas, which was found by international oil companies (IOC) while looking for oil. Therefore, actual reserves are likely to be much larger. Some countries, such as Angola, Cote d'Ivoire and the Republic of Congo have launched exploration rounds in the deep and ultra-deep waters offshore, which have proved successful in discovering larger (oil) reserves. In 1997 only, oil reserves increased by 3 Bbbl (430 mmt). Using normative equivalence factors , this represented about 3 Tcf of associated gas, i.e. 3 percent on top of the previous year's figure.

2.2 Estimated proven gas reserves, both in the associated and non-associated forms (the breakdown between associated and non associated gas is about even), amounted in 1998 to 141 Tcf (4 Tcm, about 3.5 billion toe). Although SSA accounts for no more than 3 percent of world gas reserves, they represent 30 years of the overall commercial energy demand of the region, including South Africa. Gas reserves are currently equivalent, in energy content, to oil reserves. Over the last three decades, gas reserves have increased at a much faster pace than oil reserves, bringing the gas to oil reserves ratio from 22 percent in 1971 to 40 percent in 1980, to 96 percent in 1998.

Table 2.1: Evolution of Proven Oil and Gas Reserves in SSA, 1971-1998

	Unit	*1971*	*1975*	*1980*	*1985*	*1991*	*1998*
Oil Reserves	*Bbbl*	11.8	23.8	19.8	23.0	22.3	27.3
Gas Reserves	*Bboe*	2.6	8.6	7.9	8.2	23.3	26.2
Gas Reserves to Oil Reserves Ratio	*Percent*	*22*	*36*	*40*	*39*	*105*	*96*

Source: Oil & Gas Journal.

2.3 Sixteen of the 42 Sub Saharan Africa countries are endowed with gas reserves1. While Nigeria holds 80 percent of total gas reserves, most countries range

[1] Angola, Benin, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Republic of Congo, Equatorial Guinea, Ethiopia, Gabon, Ghana, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania.

between 0.5 and 4 Tcf (15 and 110 Bcm), which is largely sufficient to cover their domestic needs, and, for some of them, to consider exports-based schemes. Reserves may be associated with oil, in particular along the Gulf of Guinea, in first place within the oil producing provinces that stretch from Angola to Cote d'Ivoire. Conversely, hydrocarbon reserves in southern and eastern Africa consist in gas-only deposits, while oil is not to be found in the area. These stranded, non-associated gas reserves are scattered throughout the rest of the continent, drawing a long bow across southern and eastern Africa, from offshore Namibia to southern Ethiopia.

Gas Uses

2.4. Ten SSA countries produce gas (whatever the final usage), for a total of 1.8 Tcf (53 Bcm). Most of the gas produced, however, is flared or vented, and this proportion is bound to increase as new oil fields are put on stream. A smaller amount of gas is used by the O&G industry itself, either as a fuel or for re-injection in oil wells to enhance oil recovery through increasing pressure in the reservoirs. Only seven countries2 -- four of them located along the Gulf of Guinea -- use gas for domestic purposes, and market it to commercial consumers outside the oil and gas industry. In total, gas accounts for a low 2.8 percent of the region's primary energy demand. Not surprisingly, the highest share is to be found in Nigeria, where gas represents 22 percent of primary energy demand, mostly for power generation. In the other gas countries, the participation of gas in the coverage of the domestic demand remains limited.

Flared Gas Recovery

2.5 Gas flaring and venting is done in oil producing countries where operators are not interested in developing gas markets – whatever the reason. Associated gas is extracted along with oil during production phase, and is generally flared or vented on the production site, sometimes after LPGs are removed from the gas stream. In a typical year, an estimated 4.8 Tcf of gas (135 Bcm) of gas is flared or vented worldwide. SSA holds by far the poorest record with respect to the ratio of gas flared or vented to gross gas production. While gas produced in SSA represents a mere 2 percent of worldwide gas output, the region accounts for 28 percent of all gas flared or vented worldwide, more than any other region. On average, oil operators in SSA flare over 70 percent of overall regional production[3] (vs. worldwide average of 4 percent), while they market only about 11 percent of the production. Up to now, in only a few cases does small-scale gas development occur, but with limited market penetration or growth, except in Cote d'Ivoire and Nigeria. If additional gas utilization projects are not implemented over the next twenty years, over half of SSA's current known gas reserves could be flared along the Atlantic seaboard, in particular in Nigeria.

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2 Angola, Cote d'Ivoire, Gabon, Nigeria, Rwanda, Senegal, South Africa.

3 Proportion of gas flared is to decrease when Nigeria's Bonny LNG project operates at full capacity.

Table 2.2: Gas Reserves and Production in Sub-Saharan Africa

Country	*Gas Reserves (Tcf)*	*Gas Production (Bcf)*	*Gas Reinjected (Bcf)*	*Gas Flared or Vented (Bcf)*	*Percent (%)*	*Other Gas Losses (Bcf)*	*Marketed Gas[4] (Bcf)*
Angola	1.6	208	42	138	*71*	5	20
Benin	<0.1						
Cameroon	3.9	73		73	*100*		
Congo, Democ. Republic	<0.1						
Congo, Republic of	3.2	47	1	46	*98*		
Cote d'Ivoire	1.1	19			0		24
Equatorial Guinea	1.3	31		28	*88*	3	
Ethiopia	0.9						
Gabon	1.2	91	21	63	*69*	3	4
Ghana	0.8						
Mozambique	2.0						
Namibia	3.0						
Nigeria	124.0	1,301	139	965	*75*	4	193
Rwanda	2.0	n/a					n/a
Senegal	0.4	2			*0*		2
South Africa	0.8	65			*0*		65
Tanzania	1.0						
Total Sub-Saharan Africa (17 countries)	147.2	1,837	203	1,313	*71*	15	308

Sources: Reserves: Oil & Gas Journal, as of 1/1999. Other data: US Department of Energy, for 1996 or 1997. **Bold case** indicates countries where gas is sold in the domestic market.

2.6 Under present oil and gas practices in many developing countries, associated gas is still considered by IOCs a by-product of oil which can hinder the oil flow – which is physically the case. In SSA, it is generally disposed of through flaring or venting for lack of adequate markets or lack of institutional and regulatory framework to support its utilization. The issue in developing associated gas recovery is purely economic, not technical, as associated gas can physically be separated from oil for further use within or outside the industry. Own use includes re-injection, either to improve oil flow, the reservoir productivity and thus increase its useful life, or to be kept in storage for later use. External usage directs gas toward consumption markets, either domestic or international, where it can be used as a fuel or feedstock. Whatever the option, associated gas recovery means a productive use of a depletable energy resource.

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4 Including own use.

Table 2.3: Gas Uses in Sub-Saharan Africa

	(Bcf/year)	*(Bcm/year)*	*Percent*
Gas Produced	1,837	52.0	*100*
Gas Flared / Vented	1,313	37.2	*71*
Gas Re-injected	203	5.7	*11*
Own Use	126	3.6	*7*
Gas Marketed	**195**	**5.5**	***11***

Table 2.4: Gas Flaring Worldwide

Region	*Gas Flared or Vented (Tcf)*	*Regionwise Breakdown of Gas Flared/Vented (%)*	*Gas Flared, as a Percentage of Gross Regional Production (%)*
North America	0.5	*11*	*2*
Central & South America	0.6	*12*	*12*
Western Europe	0.1	*3*	*1*
FSU and Central & Eastern Europe	0.7	*14*	*3*
Middle East	0.9	*19*	*9*
North Africa	0.4	*8*	*6*
Sub-Saharan Africa	**1.3**	***28***	***71***
Far East & Oceania	0.3	*6*	*3*
Total World	**4.8**	***100***	***4***

Source: Oil & Gas Journal; Cedigaz. Discrepancies may occur due to rounding

2.7 If associated gas is valued at the price of fuel oil -- its closest competitor in the industrial market – gas flaring represents an economic loss of USD 3 billion annually in SSA. Moreover, gas flaring and venting represents an environmental threat in increasing the release in the atmosphere of greenhouse gases (GHG, in particular carbon dioxide and methane), which are responsible for global warming. The steady growth of carbon emissions was declared no longer acceptable under the Kyoto protocol of 1998 that aims at mitigating global warming through the reduction of carbon emissions by industrialized countries. In SSA's oil producing countries, natural gas flaring (which produces CO_2) and venting (which frees up CH_4) represent the major source of GHG emissions, a proportion significantly larger than emissions from the combustion of all fossil fuels (including gas) fired for industrial and domestic purposes, including power generation (Table 2.5).

2.8 Associated gas recovery, however, is an expensive operation. Whether gas is used for re-injection or for outside customers, it requires the construction and the operation of a gas gathering system that collects raw gas from oil wells and transport it to a gas treatment unit where LPG are removed. It then requires powerful compressors used to either re-inject the gas into the reservoirs, or to send it through high-pressure pipeline to remote consumers. Benefits from increased oil production, LPG recovery or possible future sales of gas, must be sufficient to bring adequate returns on investments for the latter to be considered.

Table 2.5: Carbon Dioxide (CO2) Emissions from the Consumption and Flaring of Natural Gas

	Emissions from ...		*Share of Gas Flaring / Venting ...*	
	Consumption and Flaring / Venting of Gas (million ton C)	*of which: Flaring and Venting only (million ton C)*	*...in Total Gas Consumed and Flared/Vented (%)*	*...in Total Fossil Fuels Consumption (%)*
Angola	2.28	1.99	*87*	*59*
Congo (Republic of)	0.81	0.81	*100*	*75*
Gabon	0.94	0.88	*94*	*49*
Nigeria	16.04	13.19	*82*	*48*
South Africa	0.98	0.02	*2*	*0*
Sub Saharan Africa (5 Countries)	**21.46**	**16.99**	***79***	***11***

Sources: Emissions from Consumption and Flaring : EIA, US DoE. Other data: own computations.

2.9 Therefore, gas flaring recovery is usually only considered for larger projects, and it is frequently not chosen, in particular for small fields. Such large-scale recovery projects, however, are being implemented in SSA, in particular in Nigeria. The first exports-oriented project, Bonny LNG, has just started after three decades of preparation, hesitations and postponements. It is based on collecting 800 mmcfd of associated gas from the Bonny oil field for liquefaction and exports to European markets. A second project is now in the pipe, which will result in exporting up to 180 mmcfd of associated gas from the Escravos oil field area to Benin, Togo and Ghana through an offshore, 980-km long pipeline mainly dedicated to power generation.

2.10 Creating an enabling environment for gas markets, providing incentives to IOC's, evaluating projects and financing them, are possible only with the close co-operation between host governments, IOC's and investors. A review of recent efforts in this direction shows that wherever this type of approach has been applied, results have been successful in reducing or preventing associated gas flaring. The North Sea, and more recently Indonesia, Malaysia, India (Bombay High) and Algeria, are some of these projects.

Associated Gas Recovery vs. Non-associated Gas Extraction

2.11 Exploiting the associated gas from oil fields where significant amounts of gas are currently flared or vented, comes first to mind when it comes to developing gas usage and selling it in domestic markets. As suggested above, such option reduces the waste of a valuable source of energy, and contributes to improving global environment.

It also increases the quantity of domestic energy available in a given country, thus either reducing the imports of energy (where the country has a deficit), or freeing up additional quantity of energy for exports (where the country has a surplus).

2.12 Associated gas recovery, however, is considered a costly option when compared to the straight extraction of non-associated gas. The AGI has not had the opportunity to conduct a comparative analysis of both options. A previous study performed within the framework of the Nigeria Energy Assessment5 shows that several factors tend to make the economic cost of non-associated gas operation cheaper. Such factors include (i) higher well productivity; (ii) better cost-efficiency of capital expenditure due to higher reserve base; (iii) no need for gas gathering system; and (iv) no need for gas re-compression as non-associated gas is produced at a pressure that allows direct pipeline send out. The latter argument, however, is questionable in the case the non-associated gas stream is conveyed to a gas treatment plant and / or an LPG recovery unit before being sent out to the network, a highly desirable option supported by usually high profitability. While figures would certainly require to be updated, the 4 to 1 ratio in favor of non-associated gas (0.29 USD/mmbtu vs. 1.26 USD/mmbtu at the time of the study) is assumed to keep the demonstration still valid.

Small Fields Development

2.13 Although gas flaring reduction schemes remain a valid option for large-scale projects, other options look more attractive in those areas where markets are tight and their absorption capacity limited. They consist in developing small-scale projects based on small, associated or non-associated gas fields located close enough to consumption markets to make operation economic. Focusing on smaller projects is attractive because they are easier to bring to fruition; they mobilize less scarce resources and if proven successful, have great demonstration effect. Such schemes can evolve at a later stage toward projects of regional or even international dimension. In turn this can cause a positive "snowball" effect and attract interest for larger projects, for which groundwork would already have been laid.

2.14 Very often indeed, market size is an asset, no longer a problem. In most SSA countries, limited reserves perfectly suit limited domestic markets. Many gas fields house reserves ranging from 0.1 to 2 Tcf, suitable to ensure limited small-scale commercial operation over 20 years. A recent Esmap study6 has identified in central and southern Africa (except Nigeria) several dozens of such fields, including 85 deposits with less than 0.25 Tcf, 8 fields ranging from 0.25 to 0.5 Tcf, and another 8 fields from 0.5 to 1 Tcf.

2.15 ***Geographical imbalance and distance to markets***. As usual with gas, the key factor to ensure commercial viability is how close to the market is the field located. Due to counter economies of scale, the cost of a small buried pipeline is very sensitive to both the throughput and the distance, so that the cost of transmission may make a project

[5] ESMAP: Nigeria - Issues and Options in the Energy Sector, July 1993.
[6] ESMAP: Commercialization of Small Gas Fields, December 1997.

uneconomic if the market is located too far from the production site. The AGI has identified in central and western Africa several gas fields located close to potential markets (table 2.6). Some gas (and oil with associated gas) fields have been recently put in operation, in particular in Cote d'Ivoire.

2.16 In terms of distance from fields to markets, the situation is much contrasted between western and central Africa, on the one hand, and eastern and southern Africa, on the other hand. Along the Atlantic seaboard, from Cote d'Ivoire to Angola's Cabinda province, gas is available within 50 miles of most major consumption centers. This is the case, in particular, for the city-harbors of Abidjan, Douala, Libreville and Pointe Noire, all located close to offshore (and sometimes onshore) gas fields, or oil fields with associated gas. Such proximity makes geographic access to markets not really a problem, as the extra cost generated by gas transmission remains low, and suitable for projects even where demand is limited.

2.17 Conversely, in southern and eastern Africa, gas fields, whether onshore or offshore, are most often stranded in remote areas that can be located several hundred miles from main demand centers. There, gas transmission would account for a significant part of the delivery cost of gas at the city gate, which requires larger projects to be designed in order to lower transmission cost through economies of scale. Such projects are all the more difficult to design as a major characteristic of gas projects in Africa is the limited size of the markets.

Private Sector Involvement

2.18 ***Lack of economic perspectives.*** The lack of interest by the private sector has often been exacerbated by the absence of appropriate economic conditions for the downstream segments. Even the development of small-scale gas projects on a local level is known to be complex, capital intensive, and to require clusters of expertise far beyond local capabilities. Lengthy project preparation process, high upfront costs and (sometimes) the remoteness of fields from consumption centers, have often discouraged interested investors who do not consider domestic markets sufficiently attractive to develop even small-scale projects. A typical example is to be found in power generation. Industrial markets appear tight to potential investors, even in the main cities, without a lead customer able to secure both a sizable gas demand and a high load factor. Such preferred lead customer is a power plant. Most countries in the region, however, still rely on hydro projects, despite poor economics driven by huge, bulky upfront investment vs. smooth demand growth, lengthy lead time, and irregularity of hydraulic conditions, opposed to the flexibility, modularity and faster construction pace of gas-fired thermal power plants.

Table 2.6: A Sample of Gas and Oil Fields Located Close to Markets along the Atlantic Seaboard

Country	*Gas Fields*	*Type of Gas (Ass. / NA)*	*Gas Reserves (tcf)*	*Main Markets*	*Distance to Market (km)*
Senegal	Thies	NA	.13 0.4	Dakar	50
Cote d'Ivoire	Lion	NA	0.4	Abidjan	105
	Panthere	Ass.		Abidjan	105
	Foxtrot	NA	24	Abidjan	100
Cameroon	Logbaba	NA	0.1	Douala	10
	Matanda	NA	0.5	Douala	40
	Sanaga	NA	2.0	Douala	80
Equatorial Guinea	Alba	Ass.	0.9	Malabo	30
Gabon	Mbilagone	NA	0.5	Libreville	60
Congo	Kitina	Ass.	0.15	Pointe Noire	65
	Litchendjili	NA	0.25	Pointe Noire	45
Angola	Sanha	Ass.	0.34	Cabinda	
	Vanza	Ass.	0.35	Cabinda	

Table 2.7: Distance from Remote Gas Fields to Main Markets in Southern and Eastern Africa

Country	*Gas Field*	*Gas Reserves (Tcf)*	*Main Potential Consumption Centers*	*Approximate Distance (km)*
Ethiopia	Calub		Addis-Ababa	600
Mozambique	Pande	2.7	Maputo	560
			Gauteng area (South Africa)	900
Namibia	Kudu		Cape Town (South Africa)	840
South Africa	Mossel Bay	0.8	Cape Town	380
Tanzania	Songo Songo	1.2	Dar es Salaam	180
			Mombasa (Kenya)	500

2.19 ***Small gas fields, key to gas development.*** IOCs are tied by a long lasting culture dedicated to oil, and to big schemes. Some have been sitting for decades on gas fields without developing them -- and are still not ready to relinquish them. To IOCs, small gas schemes are, and will remain, an odd business -- as they are not equipped to bring them to fruition. Conversely, independent oil companies as well as downstream gas users and operators are attracted by smaller, less capital-intensive projects. They are ready to develop local or sub-regional projects that produce limited returns (limited in global terms, not in percentage) -- and they have already started to implement such projects, as in Cote d'Ivoire. Some conditions, however, need to be met:

- To develop small and medium size projects, small gas fields, whether associated with oil or not, are better targets than larger schemes which would imply the recovery of large amounts of vented or flared associated gas. The latter operation is generally costly and must be connected, at least to some extent, to gas re-injection. Moreover, current oil operation, hence gas flaring, is run by IOCs that are usually not ready to invest in gas schemes, in particular where the point of application is only local or regional. While mitigating gas flaring and venting is crucial for global environment, IOCs still need stronger economic incentives to promote such projects.

- In the beginning, a gas project is likely to develop more efficiently if it includes all physical components of the gas chain, in particular in a country that opens up to gas operation. This has been for decades a well-known pre-requisite with emerging gas industries, because gas producers need a long-term market to develop gas production while gas users need a long-term guarantee of supply. Such a prerequisite, however, may become rapidly obsolete as gas industry develops, in particular when several sources of gas supply have started to compete (like in Cote d'Ivoire). There, a regulatory framework must be implemented very rapidly to organize the gas industry in an efficient manner and to ensure free competition in the market.
- Producing gas, transporting it and using it are different businesses. A project does need to be sponsored by (at least) both the supplier at the one end and by a main gas user at the other end. There is no need, however, for a single, integrated developer. Upcoming projects can be developed by consortia that include various skills, responsibilities and areas of expertise.
- Institutional reform must accompany the emerging gas industry. On the upstream side, hydrocarbons laws are generally unclear about the ownership of gas and the responsibilities of the contractual parties, including government, vis-a-vis natural gas. Where considered, which is quite unusual, downstream regulation is done through inappropriate legislation and case-by-case, contractual arrangements. Designing a dedicated gas regulatory framework, including the industry's structure, competition management, access to markets and economic regulation is one of the incentives that should be put in place in the early days to attract private capital.

2.20 As discussed above, the current practice for associated gas which is not utilized for oil production and related activities, is venting or flaring. Governments have generally no contractual terms to entice oil companies towards using gas, and may lack the incentive to do so depending on the preference for immediate revenues over future ones. This has led to active Governments' policies to promote oil development, and the driving force is to keep the oil flowing at minimal cost. The flaring of natural gas is also a consequence of cost minimization strategy. Due to these reasons and the lack of economic incentives (whether positive or negative), neither private nor public entities are able to promote gas development in an effective manner. Efforts must therefore focus on making the net revenues from marketing gas more attractive for the operator than the financial benefits of flaring. A properly functioning institutional framework and regulatory regime is also required. However, necessary petroleum legislation needs to be protective of State interests and yet flexible enough to allow growth. A number of countries are considering amending existing petroleum laws, or adopting new ones, that address differently problems related to the development of gas reserves, and to flaring.

2.21 Many African countries now allow and encourage companies which discover gas, to develop the field, instead of the State taking over all the rights. Also, most countries are now willing to allow the foreign investor take the lead and be the operator for the gas project. The introduction of private sector power producers has opened up a large market potential for development which can be attractive to gas producers.

2.22 Utilizing gas in lieu of other fuels can lead to substantial economic, environmental and efficiency benefits. But many African countries lack the appropriate expertise to assess the viability and usage of indigenous gas resources, particularly for domestic purposes. Instead, they often have been diverted, including under outside influence, towards grandiose schemes aimed at exports, few of which so far, have materialized. Although these are not to be excluded in the long run, large projects can hardly be considered the starting point for gas development under the AGI.

2.23 A different approach is needed to minimize preparation and implementation costs, and to bring them to acceptable levels. This is why the AGI continuously and systematically targeted small-scale projects, often related to the development of small gas fields, which are easier to bring on stream. The AGI is stressing the need of gas utilization for domestic markets. Already, some African countries are making the effort to find practical ways to commercialize locally first, their natural gas. In Angola, a comprehensive effort from both the private operator and the provincial government has led to devise the Futila Industrial Park in the Cabinda province, where energy intensive industries will make use of the hitherto flared gas. Further south, newly discovered oil fields are being considered for an overall connection, through a comprehensive Gas Gathering System (GGS) that will introduce the first cross-companies cooperation to store gas in depleted field in lieu of flaring it. The scheme is complemented by a project to deliver gas to shore. Several gas utilization options are presently being considered, including recent or developing technologies such as Gas-to-Power (GTP) and Gas-to-Liquids (GTL).

2.24 Although gas markets are being established on a country by country basis, through both small and medium scale projects, the AGI considers ultimately regional development also to be an equally important medium- to long term goal. The Mozambique to South Africa gas pipeline project could be an example of regional integration. Other regional pipelines, such as the West Africa pipeline (from Nigeria to Ghana through Benin and Togo), and exports of electricity from gas-based generation (Kudu) have recently received approval from concerned governments.

2.25 ***Governments' New Approach***. During the last few years, the political and economic environment in many African countries has drastically changed. This has had a profound effect on the hydrocarbon sector. Issues relating to security of hydrocarbon supplies have receded in the near past, with these products being viewed as commodities, which should be supplied through the most cost-effective channels. Development of domestic resources is seen as justified only when gas can be produced and marketed at internationally competitive prices.

2.26 Many have recognized that the State does not make a good entrepreneur. In light of mounting social and other more pressing internal needs, such as education and health, governments have come to realize that the only way to implement gas infrastructure projects, is to allow private sector participation. Government roles have thus to be redefined. The role of policy maker is of sovereign nature, and should definitely remain at governmental level. With regard to regulation, most African governments consider that the definition and the implementation of institutional and regulatory frameworks are of political nature and should remain the responsibility of the executive authority. While the constitution of a dedicated body may be not questioned, most governments are currently not ready to implement independent agencies and to lift all political control over such bodies. These matters are discussed further in Chapter 5.

2.27 Several countries now allow and encourage companies that discover gas, to develop the field, instead of the State taking over all the rights. Also, most countries are now willing to allow the foreign investor take the lead and be the operator for the gas project. The introduction of private sector power producers has opened up a large market potential for development which can be attractive to gas producers.

2.28 ***Institutional and regulatory reform***. Efforts must focus on making the net revenues from marketing gas much more attractive for the operator than the financial benefits of flaring. A properly functioning institutional framework and regulatory regime are also necessary. In addition, necessary petroleum legislation needs to be protective of State interests and yet flexible enough to allow growth. Creating an enabling environment for gas markets, providing incentives to IOC's, evaluating projects and financing them, are possible only with the close co-operation between host governments, IOCs, and investors, which in turn can be achieved once a level playing field has been established. A review of recent efforts in this direction shows that wherever this type of approach has been applied, results have been successful in reducing or preventing associated gas flaring.

2.29 As far as downstream activities are concerned, dedicated regulation should be put in place. Main topics include the structure of the gas industry, competitive access to market (for the industry) and to product (for customers), economic regulation (prices and tariffs) as well as technical, safety and environmental standards. Chapter 5 of this report presents a deepened analysis of, and make proposals for, institutional and regulatory framework for gas downstream activities.

3

Natural Gas: Building Up New Markets

Change in Market Perception

3.1 Until recently, gas was considered a nuisance by major IOCs. Gas reserves were deemed both too big for local markets, and too small for international schemes. Capital intensive gas development was regarded as lengthy and complex, with high distribution and marketing costs, able to only generate returns over the long term from local schemes that produce income in local currencies. Alleged lack of domestic markets meant that the only options left were large, capital-intensive international gas projects, such as Liquefied Natural Gas (LNG) and regional or world-scale petrochemicals, including ammonia and methanol. Such projects require a huge amount of capital, and lead time may be considerable. They must face severe competition from similar facilities that are either located closer to markets, or based on low to very low cost gas. In addition, such export-oriented projects leave limited value added in the host country. They are not really dedicated to directly benefit local economies other than through fiscal revenue.

3.2 Now the old scheme is fading: IOCs still prefer to find oil – and it is not likely to change -- but a gas discovery is no longer a disgrace. Smaller gas schemes, whether gas is associated with oil or not, have become increasingly attractive to both operators and governments. Small independent operators are very active, and operators and gas users team up to embark in joint ventures. This new environment is quite in line with the objectives and the raison d'etre of the AGI, which are to act as a facilitator between governments and the private sector so that an enabling environment develops, within which feasible projects may be initiated and brought to fruition.

3.3 The assistance of the AGI is the more required as the private sector is less attracted in developing projects from its own initiative. For this reason, the AGI has been primarily focusing on small-scale, domestic-oriented projects that may bear less legible benefits than larger, export-oriented schemes for which foreign private financing can be mobilized more easily. As a consequence, the AGI tends to consider small and medium scale markets that can be better supplied by small to medium scale gas schemes, whether based on the development of stranded gas fields or on the valorization of associated gas.

Such larger projects like LNG, ammonia or methanol production have not been considered in the present section. Along the same lines, it is considered that recent high-technology projects are not likely to develop in SSA in the near future, as the market is not yet ready for the risks associated with them. An exception, however, has been made for Gas-to-Liquids technology, a commercially emerging, albeit technically proven option that looks particularly well suited for African markets.

A Strong Reserve Base

3.4 Limited, albeit attractive options include substituting gas for liquid fuels, which allows save economic resources by reducing fuel imports (in countries with oil deficit) or saving more oil for further exports (in countries with oil surplus). A good example of why such desirable policy should be implemented is Cameroon, where oil exports have been steadily decreasing for several years. With only about 11 years of RTP (oil) ratio, Cameroon, a long standing net oil exporter, might well become a net importer in the near future, as new oil discoveries do not make up for field depletion. Although promoting the use of natural gas could not reverse the trend on its own (only new discoveries could), developing gas in the industrial sector and for power generation would help the country remain an oil exporter for an added period of time, and give IOCs more time to pursue exploration campaigns.

3.5 Table 3.1 shows that most gas countries are net oil exporters, in particular those located in oil provinces along the Gulf of Guinea. Actually, all gas countries also produce oil, except South Africa7 and Senegal. Significant discoveries have recently increased RTP (oil) ratios in some countries, such as Angola and the Republic of Congo. Oil RTP ratios, however, remain much lower than gas RTP ratios. They range from 11 to 29 years, with a (non-weighted) average of 24.5 years for the seven oil countries located along the Gulf of Guinea (table 3.1). Conversely, most RTP (gas) ratios are extremely high, in the range of 40 to 90 years, except for Angola, South Africa and Gabon. For the nine SSA gas countries, average RTP ratio is three times larger for gas than for oil.

Oil and Gas Demand

3.6 At regional level, energy demand in SSA is still very much met by traditional, non-commercial fuels, in particular in the residential and commercial sector. While the use of commercial energy is logically higher in SSA's more developed countries, charcoal (in larger cities) and fuelwood (in rural areas) still cover 60 to 95 percent of overall energy needs at country level. The demand of commercial energy remains concentrated in urban areas. Except in South Africa, coal is almost absent from the energy market. The bulk of commercial energy is provided by oil products and hydro-power, and, in some countries, by natural gas.

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7 South Africa produces synthetic oil from coal and gas, but is not a primary oil producer.

Table 3.1: Oil Trade and Oil and Gas Reserves-to-Production Ratios in SSA Gas and Oil Producing Countries

Country	Net Oil Trade[8] Situation (mbpd)	Oil RTP Ratio (years)	Gas RTP Ratio (years)
Angola	686	20.2	7.8
Cameroon	86	11.0	53.5
Congo, Republic of	194	15.6	68.1
Cote d'Ivoire	(43)	13.7	43.8
Equatorial Guinea		1.3	41.9
Gabon	348	19.0	13.2
Nigeria	1,663	29.1	95.3
Senegal	(24)	0	
Sub-Saharan Africa (selected countries)	**2,690**	**24.5**	**74.9**
South Africa	(220)	0	12.0

Sources: Oil & Gas Journal; EIA, US DoE. Oil and gas production: 1998. Oil and gas reserves: 1/1999. Oil exports and imports: 1996. Oil production includes crude oil, NGL and other liquids. RTP ratio: Reserves in 1/1999 to 1998 production

3.7 Oil demand in Sub-Saharan gas and oil countries9 amounted to 35 million tons in 1997, of which 76 percent was consumed by South Africa and Nigeria. About half of it is used for transportation, with the share of diesel oil increasing faster than that of motor gasoline. Other major uses includes electricity generation and transformation in the refineries (14 percent), households, commercial establishments and agriculture (13 percent), the industrial sector (9 percent), while the balance is used for non-energy uses (chemical feedstock), or is wasted in technical and non technical losses. Gas usage in the industrial sector remains modest, including in the above three countries.

3.8 Natural gas accounted for 27 percent of the overall hydrocarbon demand. The share of gas in the demand may vary significantly. In Angola, Cote d'Ivoire and Nigeria, gas accounts already for one-third and above of total demand, in particular due to power generation.

Traditional Gas Markets

3.9 Traditional gas markets (residential and commercial sector; conventional industry) in Sub-Saharan Africa are, and will remain, narrow. The potential demand of the residential and commercial markets is limited to domestic uses (cooking and water heating), which makes the profitability of dedicated gas networks unlikely. While gas requirements in the conventional industrial sector are not negligible, they are concentrated in a limited number of cities where the size of the industrial market has reached the critical mass that could trigger distribution projects. Gas demand development should thus be driven by more recent applications which have either already started to be implemented in Africa, such as gas-based power generation, or which still are under development with a high potential in Africa, such as gas-to-liquids.

[8] Oil exports minus oil imports (includes crude oil and petroleum products).
[9] Domestic demand, i.e. exc. bunkers.

Table 3.2: Oil and Gas Demand and Supply in SSA Oil and Gas Countries

	Domestic Oil Demand (mt)	*Net Oil Imports[10] (mt)*	*Gross Oil Products Imports (mt)*	*Domestic Gas Demand (mtoe)*	*Percent of Gas in Commercial Energy Demand*
Angola	1,117		62	613	*35*
Cameroon	816		14		
Congo, Republic of	317		5	4	*1*
Cote d'Ivoire	1,259	537	302	619	*33*
Ethiopia	745	383	472		
Gabon	609		209	89	*14*
Ghana	1,134	894	183		
Mozambique	672	702	702		
Nigeria	9,265		40	5,261	*36*
Senegal	1,134	709	399	26	*2*
Tanzania	584	560	171		
Sub-Saharan Africa (11 countries)	**17,573**	**3,785**	**2,559**	**6,612**	*27*
South Africa	17,871	12,616			

Source: IEA: Energy Statistics of Non-OECD Countries, 1997 (1999 Edition), exc. gas in Cote d'Ivoire.

Residential and Commercial Sector

3.10 Like in many developing regions, climatic conditions in Sub-Saharan Africa do not favor the economic operation of urban gas networks dedicated to supply the residential and commercial market. Such networks have developed in only two countries, South Africa and Cote d'Ivoire, and they are currently declining. Gas networks were first developed in Johannesburg, Cape Town and Port Elizabeth by municipal utilities to provide households with town gas for cooking, based on the distillation of the country's abundant, cheap coal. Lack of appropriate maintenance along with increasing operating costs led operators to pull out of the town gas business, which only remains to a limited extent in these cities. In Abidjan, a private operator took a different route and built a residential network in the 1970s to supply piped LPG for cooking and water heating. In spite of high distribution cost the operation proved successful and supplied up to 12,000 households and commercial establishments at its peak. There again, insufficient maintenance effort led the system to progressively decay while increasing payment arrears made the operation unmanageable. It is no longer considered suitable for operation.

3.11 The main issue with residential gas distribution in warmer regions is the limited gas demand required by households. Cooking and water heating demand (called "base load") typically account for around 300-400 cubic meters of natural gas on a yearly basis (30-40 cfd), which is low in comparison with any demand that includes space heating. In the base load market, gas would mainly compete with bottled LPG. Based on a typical economic cost of USD 10/mmbtu11, the second best option (here LPG) would

[10] Includes crude oil and oil products.
[11] Bottled, delivered at user's gate. USD 10/mmbtu is equivalent to USD 480/ton.

generate a yearly bill of USD 120-150 per household for the typical demand mentioned above. Considering that the construction cost of a gas network would typically range between USD 500 and 1,000 per household – in particular in low density residential areas where construction and maintenance costs are higher -- such revenue would prove insufficient to enable the gas operator to repay the capital expenditure of the system, and to operate and maintain it in a sustainable manner, unless customers are willing to pay a very high premium for the uninterrupted availability and readiness of piped gas.

3.12 Since there is no need for space heating, the only option to increase gas demand would be to develop the use of gas for air conditioning. There, the main competitor is high cost electricity. Gas could compete, with reasonable chances of success, in new commercial buildings, such as office buildings, hotels and hospitals. Gas-based air conditioning technology, however, has developed mainly in North America and Southeast Asia, and it is not widely known and used in other regions. The introduction of gas-fired appliances would thus require a strong promotional effort from specialized dealers, and it is expected to be costly. In addition, individual appliances (for houses and small commercial establishments) are significantly more expensive than those based on electricity, which makes their penetration in the market more difficult, even where the cost of gas is lower than that of electricity.

Conventional Industry

3.13 While the gas industry started worldwide in the mid-1850s with the construction of large town gas networks dedicated to street lighting and home cooking, the massive development of natural gas began one century later when the medium and large-scale industry considered substituting gas for heavily polluting coal and high sulfur fuel oil (HSFO). In almost every single industrial branch, gas has become in less than three decades the preferred fuel in those activities where cleanliness, flexibility and easy use are key factors to ensuring high quality output while bending operating costs. This is the case in such industries as food processing and refrigeration, vegetal oil processing, ceramic and tiles, glass and metal surface treatment, all industrial branches that usually constitute the mainstay of industrial activities in larger African harbor-cities.

3.14 On average, the industrial sector accounts for 27 percent of the final energy demand of SSA's gas countries12, a figure equivalent to that of the residential and commercial sector, about half of transportation requirements. Natural gas already represents a fairly high share of industrial demand, due to the weigh of Nigeria in the SSA's overall industrial demand. Where gas is not developed, the industrial demand is met by electricity and oil, while coal is virtually absent from the fuel mix, except in South Africa. Due to high cost – and sometimes limited availability -- electricity is called mainly for these applications where using fossil fuels or steam is not technically feasible, e.g. to drive motors, and for specific utilization.

12 In commercial energy of the 11 gas countries listed in table 3.4. Does not include South Africa.

Table 3.3: Final Energy Demand in the Main Consuming Sectors[13]

	Final Energy Demand (mtoe)	*Share of Total Demand (%)*	*Share of Industry Demand (%)*
Industry	5,425	27.2	*100.0*
Oil Products	1,544	7.8	*28.5*
Natural Gas	1,344	6.8	*24.8*
Electricity	2,513	12.6	*46.3*
Coal	24	0.1	*0.4*
Transportation	8,977	45.1	
Residential & Commercial[14]	5,510	27.7	
Total	**19,912**	**100.0**	

Source: IEA: Energy Statistics of Non-OECD Countries, 1997 (1999 Edition)

3.15 The main issues in developing industrial gas networks in Sub-Saharan metropolises deal with the size of the market on the one hand, and the constitution of the fuel mix, which gas will have to compete with on the other hand. Some discrepancies between statistical sources may make it difficult to get a clear picture of the detailed breakdown of the sectoral demand of energy products. In particular, it generally proves uneasy to allocate middle distillates (gas oil and diesel oil) to either industrial usage or transportation. Pre-feasibility studies conducted within the preparation of industrial gas networks projects in Abidjan and Douala evaluate the gas potential market at 80,000 and 45,000 toe in the medium term, respectively. Preliminary estimates for smaller industrial markets, such as Gabon (Libreville and Port-Gentil, where gas is already in use) and Congo (Pointe Noire) result in potential markets ranging between 4,000 and 10,000 toe.

3.16 Most of the industrial demand is currently met by fuel oil. Table 3.4 presents the industrial demand of some fuels used by the industrial sector in SSA gas countries on the one hand, and the overall oil demand of the sector on the other hand, based on the latest IEA statistical data. In most SSA gas countries, fuel oil is used to a large extent in the industrial sector, due to the high share of hydro in power generation. Also, thermal power generation is typically required for peak shaving purposes, or to supply remote, non-interconnected networks, which is usually achieved through diesel oil-fired gas turbines or reciprocating engines. It is thus believed that most of the fuel oil demand is actually consumed by the industrial sector. The picture is quite different for diesel oil where demand is believed to be used to a large extent for transportation.

3.17 In the beginning, natural gas has to compete mainly with fuel oil, a relatively low cost energy source, which does not enable natural gas to take full advantage of its intrinsic qualities. Standard burner-for-burner conversion gives natural gas only a limited premium over fuel oil, based on slight improvements in burner efficiency, maintenance cost and increased lifetime of the equipment. In steam raising

13 Only commercial energy.

14 Including agriculture

uses, the premium does not go beyond a few percent. In high temperature uses, e.g. furnaces and kilns, the premium may be higher, but it seldom exceeds 7-8 to percent, unless the thermal process is somewhat modified. Plain substitution thus restricts competition between gas and oil close to the "per btu" value of each fuel.

3.18 In older gas countries, efficient gas-dedicated equipment has progressively replaced conventional, energy-intensive processes, and such historical process is expected to be similar in SSA countries. As an example, the direct use of the flame often enables the plant's operator to replace, totally or in part, steam or hot water by gas as the plant's primary energy carrier, thus to get rid of heat exchangers, which reduces significantly the overall heat losses. In addition, natural gas flexibility allows for fine-tuning the heat supply, which benefits both the quality of the output and the global efficiency of the thermal process.

Table 3.4: Oil Demand by the Industrial Sector in SSA Gas Countries

	Fuel oil (a) (mty)	*Middle Distillates (b) (mty)*	*Other Oil Products (c) (mty)*	*Total Oil Products (mty)*
Angola			15	15
Cameroon	49			49
Congo, Republic of	4			4
Cote d'Ivoire	62	71	8	141
Ethiopia	73	30		103
Gabon	32	86	10	128
Ghana	53	38	12	103
Mozambique		10	1	11
Nigeria	710	40		750
Senegal	85	50		135
Tanzania	105			105
Sub-Saharan Africa (11 countries)	**1,173**	**325**	**46**	**1,544**
South Africa	350	859	135	1,344

Source: IEA, Energy Statistics and Balances of non-OECD Countries in 1997 (1999 Edition).
(a) Includes power generation. (b) Gas oil, diesel oil and kerosene. (c) LPG and feedstock.

Power Generation

3.19 In the recent years, power generation has become a major potential market for natural gas. In emerging gas industries, including a gas-based power plant is often the pre-requisite for a gas project to take off, as the successful gas history of Cote d'Ivoire has recently highlighted. Natural gas can play a role either as a substitute to currently used liquid fuels, or as a means to increase installed capacity through diversification, where required. A considerable market exists, simply expressed by the fact that 92 percent of the 610 million people living in Sub-Saharan Africa have so far no access to electricity.

3.20 One of the most efficient ways to build up a gas market is thus to focus on the fuel requirements of the power generation sector. With regard to the existing potential market, power plants are often large consumers of petroleum products, compared to industry, even in those countries where hydro power prevails, i.e. most of Sub-Saharan Africa15. Their level of demand, except for peak shaving purposes, is for the most part stable throughout the year, which helps keep gas production cost low. In conventional power stations, gas can displace liquid fuels in steam turbines or reciprocating engines. Such market, however, is often limited by the real quantities of oil products actually consumed by thermal generation, as well as by the location of thermal power plants. Even in countries where thermal capacity accounts for a notable proportion of the total installed capacity, thermal plants are often used at a low load factor, due to the high cost of fossil fuels or to the poor operating condition of the units.

3.21 In many SSA countries where rainfalls have been erratic and droughts more frequent, diversification in power generation appears critical. Power outages are a common feature in Sub-Saharan Africa, although part of them are attributable to transmission and distribution failures rather than generation conditions. Hydro projects, besides the limited -- and shrinking -- capacity of existing public institutions unable to finance new projects, are environmentally risky and no longer economically viable. They have proved unable to provide acceptable service under severe climatic conditions, and cash-short power utilities have no longer the resources to correctly maintain back-up thermal facilities, set alone promoting new hydro schemes.

3.22 Since the mid-nineties, improving technology coupled with sharply decreasing construction costs have made gas-based power generation facilities the most efficient option to develop additional capacity, whether for base load or peak shaving. Techno-economic achievements are tremendous: the efficiency of combined cycle power plants now is close to 60 percent, almost 15 percent up from where it stood ten years ago. In the mean time, costs are plummeting due to increasing standardization of materials, as more equipment is available "off the shelf". Cost per kW of installed capacity is now as low as USD400-500 for combined cycles, from nearly twice as much in the beginning of the decade. In addition, the wide range of capacities available, the flexibility of the implementation schedule due to modularity, and short construction time make these technologies well adapted to emerging economies that are characterized by limited market base and slow to moderate growth rates.

[15] With notable exceptions, such as South Africa.

Table 3.5: Electricity Demand and Supply in SSA Gas Countries

	Electricity Demand (GWh)	*Production from Hydro (GWh)*	*Production from Fossil Fuels (GWh)*	*Net Imports (GWh)*
Angola	794	1,006	103	0
Cameroon	2,517	3,092	36	0
Congo, Republic of	541	425	6	114
Cote d'Ivoire	2,727	2,022	1,191	34
Ethiopia	1,325	1,170	66	0
Gabon	906	740	267	0
Ghana	5,745	6,148	7	(397)
Mozambique	893	791	214	203
Nigeria	10,350	5,593	9,586	0
Senegal	1,050	0	1,261	0
Tanzania	1,700	1,449	485	44
Sub-Saharan Africa (11 countries)	**28,548**	**22,436**	**13,222**	**(2)**
South Africa	187,646	4,700	193,005	(6,612)

Source: IEA, Energy Statistics and Balances of non-OECD Countries in 1997 (1999 Edition). Figures between brackets indicate net exports.

3.23 Building up gas infrastructure will involve institutional and regulatory changes, leading to adequate power for consumers and inviting contributing independent power producers (IPPs). In the process, indigenous companies can learn more about changes in the industry, by joining forces with new entrants. The recent growth of IPP's willing to work outside their traditional areas is expected to contribute to increased gas demand. In addition, IPP's prefer gas-fired plants which are modular in structure, are cheaper than conventional plants, have shorter lead times and show higher efficiency. Results from around the world show that the power sector is generally the key to developing a natural gas infrastructure. While other sectors are also important in developing this infrastructure, industry experts agree that the gas purchase contract by the power generator is the key to securing financing and getting the project off the ground. Once available, gas then becomes attractive to other potential users, both for its physical and intrinsic qualities as well as for its comparative advantages.

3.24 In countries where gas is not available, gas trade (and gas-based electricity trade) is an adequate answer, as a regional market approach can help excess capacity here meet suppressed demand there. In addition to providing basic electricity supply to those countries that are not endowed with gas resources, energy trade constitutes a reliable back-up for hydro-supplied countries. It, however, requires technical and institutional coordination as governments have a role to play in opening markets in a sector which is still often regarded as strategic.

Gas-to-Liquids

3.25 The production of liquid fuels from a different primary energy source is nowadays based on a well-known technological process from German origin (the Fischer-Tropsch [F-T] synthesis) that dates back to the early 1920s[16]. As long as the price of the barrel remained moderate, i.e. until the late 1970s, synthetic oil ("synfuel") was mainly produced out of coal in a few large-scale operations located in countries where access to oil was restricted. Although a proven technology, the development of the process was hampered by adverse economics caused by huge capital investment and poor overall efficiency, in particular in coal-based operations. Nowadays, technical improvements, in particular with regard to catalysts, are concurring to improve global economics and to limit the effect of economies of scale, thus downscaling the threshold above which production units may become competitive.

3.26 Typical technology includes a three-step process that produces subsequently synthesis gas; a mixture of straight chain hydrocarbons; and the final, desired product(s). Specific technologies of each component vary according to operators. The first step is common to the production of several other chemical products, including methanol and DME[17], as well as the reduction of iron ore. It consists in producing synthesis gas – a mixture of carbon monoxide (CO) and hydrogen – that will serve as a feedstock for the second reaction. For this first step, natural gas has increasingly become the preferred primary fuel due to easy handling and increased efficiency over coal. In spite of better efficiency, the production of synthetis gas (syngas) still accounts for the larger share of the plant's cost – up to 60 percent.

3.27 In the second step, the F-T synthesis converts synthesis gas into hydrocarbons of varying chain length and molecular weights. It is a catalytic reaction (usually iron or cobalt) that by-produces water and carbon dioxide (CO_2), along with considerable amounts of heat that can be used to generate electricity through a steam turbine, thus enhancing the overall efficiency of the process. In the final step, products released by the F-T reaction are upgraded to release either light synthetic crude oil ("syncrude"), or middle distillates[18] such as diesel oil / gas oil, associated to kerosene and naphtha.

3.28 The production of diesel oil is of particular interest in SSA where demand from both transportation and industrial sectors is increasing at a fast pace that exceeds the capabilities of local refineries. Moreover, synthetic diesel oil is a high-quality product that has a very low sulfur and aromatic content, a high octane index and contains fewer particulates; it burns very cleanly in a compression-ignition engine, which gives it a strong environmental premium.

3.29 Table 3.6 presents the middle distillates (gas oil and diesel oil) supply and demand patterns in eleven gas countries in 1997. Figures show that imports are more

[16] Another route converts gas to methanol, then to liquid hydrocarbons. Commercialized by Mobil in New Zealand in the 1980s, it is considered not economic and the plant was shut down.

[17] Dimethyl-ether, an aerosol propellent.

[18] Along with high quality specialty products, e.g. waxes and lubes.

than three times higher than exports, and represent 22 percent of domestic demand19. All countries (exc. Nigeria and Congo) are net importers of middle distillates, including those countries where refineries are operated. Assuming that all exports from oil refining countries are directed to countries within the region, it can be roughly estimated that regional imports from outside SSA account for at least one-sixth of domestic demand.

Table 3.6: Gas Oil/Diesel Oil Demand and Supply in SSA Gas Countries (1997)

	Domestic Demand (mt)	*Production (mt)*	*Exports*[20] *(mt)*	*Imports (mt)*
Angola	262	486	50	56
Cameroon	331	385	7	7
Congo, Republic of	82	92	10	
Cote d'Ivoire	573	484		99
Ethiopia	136	116	28	49
Gabon	298	162		137
Ghana	390	315		101
Mozambique	296			264[21]
Nigeria	1,294	3,002	164[22]	27
Senegal	322	242	9	104
Tanzania	237	148	12	102
Sub-Saharan Africa (11 countries)	**4,221**	**5,432**	**280**	**946**
South Africa	4,804	5,147		

Sources: IEA, Energy Statistics and Balances of non-OECD Countries in 1997 (1999 Edition).

3.30 At 50 percent efficiency – the level currently reached by GTL technology -- it takes 10,000 cf of natural gas to produce 1 bl of synfuels. A small-scale unit (5,000 bpd – 200,000 tons per year, i.e. the production level required by African economies) thus requires 50 mmcfd of gas, i.e. an amount of gas equivalent to that consumed by a 350 MW combined-cycle power plant running on base load. With as low as 0.5 tcf (14 bcm) of recoverable reserves, a gas field may supply such a production unit for 25 years.

3.31 The major issues are that construction and operating costs remain high, and the number of real-size projects is limited. High-cost GTL plants operate in South Africa (Mossel Bay) and Malaysia (Shell, at Bintulu), while plans for large-scale plants exist in Australia and Qatar. The large-scale unit built by Mobil in New Zealand has been shut down. Developers of GTL technology claim that small-scale units can show positive economics with production levels as low as 2,000 to 5,000 bpd of oil products.

19 Important smuggling, in particular from Nigeria to neighboring countries, is likely to distort official demand and supply figures in the sub-region.

20 Not including international marine bunkers.

21 Not including 33 mt of "transfers" (considered unofficial imports through smuggling).

22 Not including 1,491 mt of "transfers" (considered unofficial exports through smuggling).

These promoters, however, such as Syntroleum and Rentech, develop technology and sell licenses to oil companies, but they do not have the financial power that could enable them to take the risk to develop projects on their own without the support of an oil company. This is a major reason why no full-size, small-scale project has been built and operated so far.

3.32 Although developers estimate that full-scale commercial projects can be built for as low as USD 18,000 to 22,000 per barrel of daily capacity, the lowest capex to date of a commercially-run unit amounts to USD 30,000 per bpd. Based on such assumptions23, a recent Esmap-sponsored study24 shows that a GTL plant should have a capacity of 20,000 bpd to economically produce diesel oil at USD 22/bl (i.e. crude oil at USD 16-17/bl), using gas delivered at USD 0.60/mmbtu.

3.33 In Africa, however, the global economics of GTL projects may prove much more attractive than in large oil producing or consuming countries. CIF costs of oil products in SSA are high, in particular when they are imported, due to costly freight applied to the small cargoes required by African markets. In western Africa, the demand already exceeds the production of the regional refineries, so that the sub-region has become a net importer of middle distillates, in particular diesel oil and jet fuel. To meet growing traffic needs, three conventional options can be considered: (i) the expansion of the capacity of existing regional refineries; (ii) the construction of hydro-cracker(s) in these refineries to increase the output of middle distillates out of fuel oil in excess; and (iii) additional imports. The first two options require huge amounts of capital, and the decision may depend on several factors, the demand of middle distillates being only one of them. All three options require to either allocate to domestic markets additional quantities of crude oil that could be sold on the international market (in oil surplus countries), or to increase the dependence on imported energy (in oil deficit countries).

3.34 To develop GTL units based on local gas fields is an attractive alternative, provided that crude oil is in the range of USD 20-24/bl – or above. Table 3.8 shows that, based on data available in the industry, a small-scale GTL plant (5,000 bpd) can produce diesel oil / gas oil under economic conditions as soon as crude oil is over USD 21.60/bl, where gas is available at plant's gate at a reasonable USD 1.00/mmbtu. Due to higher freight costs (see above paragraph) the diesel / crude index for Africa that expresses the ratio of the spot price of diesel / gas oil delivered to African markets, to the price of crude is considered higher (140) than that generally admitted for larger cargoes.

[23] CapEx: 30,000 USD/bpd; discount rate: 15 percent; lead time: 3 years.

[24] Commercialization of marginal gas fields, December 1997.

Table 3.7: Gas Oil/Diesel Oil Demand in Selected SSA Countries (1990-1997)(mt)

	1990	*1992*	*1994*	*1996*	*1997*	*Yearly Increase (%)*
Angola	86	90	85	127	262	*17.3*
Cameroon	347	300	317	318	331	*-0.7*
Congo, Republic of	98	80	84	82	82	*-2.5*
Congo, Democratic Rep.	328	301	339	341	341	*0.6*
Cote d'Ivoire	339	338	533	552	573	*7.8*
Gabon	163	176	174	232	298	*9.0*
Ghana	275	294	394	390	390	*5.1*
Kenya	592	599	564	674	662	*1.6*
Mozambique	210	234	230	230	296	*5.0*
Nigeria	1,396	2,280	1,596	1,278	1,294	*-1.1*
Senegal	213	250	245	258	322	*6.1*
Tanzania	207	195	195	201	237	*2.0*
Sub-Saharan Africa (12 countries)	**4,254**	**5,137**	**4,756**	**4,638**	**5,088**	***2.6***

Sources: IEA, Energy Statistics and Balances of non-OECD Countries in 1997 (1999 Edition).

Table 3.8: Main Characteristics of a Small-scale GTL Plant

	Unit	*Characteristics*
Nominal output capacity	bpd	5,000
CapEx per bpd of capacity	USD	30,000
O&M cost, not including natural gas	USD/bl	7
Natural gas demand	mmcfd	50
Natural gas demand over 20 years	Tcf	0.34
Cost of gas at plant's gate	USD/mmbtu	1.00
Cost of diesel oil produced	**USD/bl**	**30.30**
Diesel oil / Crude oil index (SSA)		140
Opportunity cost of crude oil	**USD/bl**	**21.60**

Sources: Esmap study (mentioned above); own assumptions. Discount rate @ 12 percent.

3.35 Where gas is cheaper, e.g. if the GTL plant is located next to a gas field, which requires no transmission line, then the plant is economic as soon as crude oil is above USD 18/bl. Conversely, crude oil needs to be quoted at a minimum of USD 25 if the cost of gas reaches USD 1.50/mmbtu. The variation of other parameters tend to increase (or decrease) the cost of the output by up to 13 percent.

Table 3.9 – Sensitivity Analysis

	Production Cost of Diesel / Gas oil (USD/bl)	*Relevant Price of Crude oil (USD/bl)*
Base Case Scenario[25]	**30.30**	**21.60**
CapEx + 15 percent	32.30	23.10
CapEx + 30 percent	34.30	24.50
CapEx – 15 percent	28.30	20.20
Natural gas @ USD 1.50/mmbtu	***35.30***	***25.20***
Natural gas @ USD 0.50/mmbtu	***25.30***	***18.10***
Discount rate @ 15 percent	33.30	23.80
Delivery cost of products @ USD 3/bl	33.30	23.80

[25] See Table 3.8, with discount rate @ 12 percent; no delivery cost of products.

4

LPG

A Fuel Too Long Overlooked

4.1 Through ESMAP, the World Bank has been very active for almost two decades in promoting efficiency in the household energy sector. Significant efforts have been dedicated to improving the production process and the use of biomass, in particular charcoal, and of some basic commercial fuels such as kerosene. However, LPG was long regarded -- and not only within the Bank -- as «a fuel for the rich ones» and was not given all the attention it deserves. While it is true that LPG is by far the most sophisticated of the household energy sources available in developing countries – and as such was often the most expensive one, besides electricity -- this somewhat wrong perception is changing rapidly.

4.2 Why is the development of the LPG industry so important in emerging economies? The answer lies in one word: people. In spite of the benefits LPG can bring to the industrial sector, in particular for those activities which requires a clean, easy to control fuel, such as the food industry, glass and ceramics, drying of textiles, etc., LPG remains mostly a household energy. It is easy to transport, easy to handle, its implementation does not require capital intensive infrastructure facilities, and it is generally safer than liquids -- provided that it is correctly stored and handled. Household energy remains a very sensitive topic in emerging economies:

- because of its connection with food preparation, household energy contributes to meet one of the fundamental needs of the population; it thus retains a strong political and social content;
- it represents a significant part of the household's budget, in particular in poorer households;
- in spite of the emergence of new technologies, such as solar energy, and surprising as it may seem, there has been little improvement in decades in the energy household sector.

4.3 LPG must be taken in consideration as the extraction of LPG (and condensate) from the natural gas stream can substantially increase the global revenue yielded by a gas project, thus improving its overall economics. While LPG is sold to marketers, the remaining natural gasoline is sent to the refinery to increase the yield of white products. A well-known operation, LPG stripping requires limited investment for high returns, in particular in those countries where the delivery cost of imported LPG is kept high by limited storage facilities and the small size of LPG cargoes.

4.4 In addition to exploiting gas resources, the extraction and production of LPG and condensate from wet gas is one of the most profitable activities a country can engage in. If gas quality permits, the additional investment required to extract LPG is relatively small compared to the payouts. Introduction of LPG in certain African countries has been a success given its weight/performance ratio. LPG can be bottled and transported to areas which are out of reach of gas pipelines, where consumers can see the benefits for themselves and are willing to pay the premium for a versatile and clean fuel. Developing LPG for households and in the small commercial sector helps protect the forests by reducing the need for charcoal and fuelwood. It can also contribute to significantly reduce the energy bill of the households, in particular the poorest ones, because the cost of delivering charcoal is getting higher as sources of production get farther away from larger cities. Ongoing studies are finding that introduction of LPG has slowed down or even arrested the rate of deforestation near urban centers.

Narrowing the Gap

4.5 In several emerging economies, in particular in Southeast Asia and, to a lesser extent, in Latin America, the LPG industry presents the characteristics of a mature industry. Consumption levels as well as penetration factors are high, the production and distribution networks are organized and work well, and the institutional environment is able to accompany efficiently the growth of the industry. As a result, LPG is widely accessible, shortage is often non existent, and per capita consumption is high.

Table 4.1: LPG Demand in the Residential Sector in Selected Emerging Economies

	Yearly Demand (mty)	*Population (million)*	*GDP per capita (USD)*	*Demand per capita (kg)*	*Demand per $1,000 GDP (kg)*
Sub Saharan Africa	**510**	**593**	**515**	**0.9**	**1.7**
Low income South Asia	4,580	1,060	397	4.3	10.9
Middle income East Asia	3,685	340	1,746	10.8	6.2
Middle income Latin America	1,771	80	2,155	22.1	10.3
North Africa	4,082	121	1,398	33.7	24.1

Sources: *LPG*: MCH through WLPGA; *GDP and population*: World Bank

4.6 On another hand, other countries and regions still struggle to satisfactorily implement distribution systems that would meet the demand of the population. Among them, most countries in Sub Saharan Africa have not reached yet the critical mass of business that would allow the industry to smoothly develop by itself, often because the institutional and / or the economic bases are still to be strengthened, and sometimes just need to be put in place. An objective of the AGI is to play a role to help emerging economies improve the access of the population to better household energy.

Commercial Energy: A Tiny Slice of Total Energy Demand

4.7 In Sub Saharan Africa (SSA), commercial energy remains out of reach of most households. According to the yearly activity report of the South African power utility Eskom, based on the actual number of electric connections in 13 countries in southern and central Africa (not including South Africa itself), no more than 8 percent of households have access to electricity. And where commercial energy is available, it is usually expensive, the quality of service is often poor, and it often needs to be supplemented by traditional energies, due to imbalance between supply and demand.

4.8 In the residential sector, biomass is still the mainstay of food preparation and water heating. Estimates by the International Energy Agency in 16 SSA countries show that commercial energy (oil products and electricity) represents a mere 3 percent of the total energy used by households, while the balance is met by biomass. Although biomass presents some comparative advantages vis a vis commercial energy -- with regard to availability, retail price and purchase flexibility -- it is less efficient (measured in useful energy) and puts increasing strain on remaining woodlands. In most countries, deforestation is proceeding at a very quick pace, while reforestation remains shy of reasonable targets. Since 1980, the World Bank estimates that SSA has lost close to 15 percent of its forest area (up to 25 percent in some countries along the Gulf of Guinea seaboard), and woodlands do no longer account for more than 26 percent of the region's land area.

4.9 Table 4.2 illustrates the limited share of commercial energy in the residential and commercial sectors in selected countries of Sub-Saharan Africa.

4.10 Though woodfuel demand is not the only factor responsible for wood cutting (the lumber industry and the search for more agricultural land also take a heavy toll), increasing the share of commercial energy will help alleviate deforestation, in particular in Sahelian areas and around larger cities. It will also curb the cost of household energy, as the price of charcoal, in particular in Africa's larger cities, is steadily increasing due to higher transportation cost as production sites get ever farther from consumption centers. While electricity tariffs, in addition to the cost of electric appliances, is likely to keep electric cooking out of reach of a large majority of households, the high versatility, convenience and increased availability of LPG should make it in the near future the preferred fuel for domestic uses where existing distribution infrastructure is improved and suitable pricing mechanism is introduced.

Table 4.2: Biomass vs. Commercial Energy (R&C sectors) in Sub Saharan Africa

	Biomass (mtoe)	*Oil Products[26] (mtoe)*	*Electricity (mtoe)*	*Biomass (%)*	*Oil Products (%)*	*Electricity (%)*
Angola	3,726	56	55	*97.1*	*1.5*	*1.4*
Cameroon	3,660	121	70	*95.0*	*3.1*	*1.8*
Congo, Republic of	691	51	27	*89.9*	*6.6*	*3.5*
Cote d'Ivoire	2,467	105	119	*91.7*	*3.9*	*4.4*
Ethiopia	15,592	30	48	*99.5*	*0.2*	*0.3*
Gabon	688	47	45	*88.2*	*6.0*	*5.7*
Ghana	3,404	186	159	*90.8*	*5.0*	*4.2*
Kenya	6,757	149	146	*95.8*	*2.1*	*2.1*
Mozambique	5,716	240	52	*95.1*	*4.0*	*0.9*
Nigeria	60,212	866	834	*97.3*	*1.4*	*1.3*
Senegal	1,080	87	38	*89.7*	*7.2*	*3.1*
Tanzania	10,050	78	118	*98.1*	*0.8*	*1.1*
Sub Saharan Africa (12 countries)	**114,043**	**2,016**	**1,710**	***96.8***	***1.7***	***1.5***
South Africa	7,159	717	5,686	*52.8*	*5.3*	*41.9*

Source: IEA: Energy Statistics and Balances of Non-OECD Countries, 1997 (1999 Edition)

LPG Demand and Supply Patterns Remain Strongly Distorted

4.11 At about 510,000 tons, LPG consumption in the residential sector of SSA remains well below the yearly consumption of other developing regions. With but a few exceptions, yearly per capita demand in most SSA countries ranges between 0.5 and 2 kgs, the average consumption being about 0.9 kg, which remains low when compared to South Asia, South America and North Africa.

4.12 Limited LPG consumption in SSA is often blamed on the population's low income level. While it is obvious that low income level limits access to most goods and services, included LPG, facts show that supply constraints, inadequate institutional framework, including pricing and subsidies, and lack of incentives for marketers, not income level, are by far the majors reasons for keeping LPG consumption low. A clear illustration of the upside potential is given by the case of Cote d'Ivoire, where the introduction in 1994 of a new entrant developed the potential market well beyond the then level of consumption, while LPG sales by traditional marketers remained unchanged. It is quite likely that the conditions in other cities in Sub Saharan Africa are similar to those that prevail in Abidjan.

[26] Mainly kerosene and LPG.

Table 4.3: LPG Demand in Selected Countries in Sub Saharan Africa

	Yearly Demand in the Residential Sector (tons)	*Demand per capita (kgs of LPG per year)*	*GDP per capita (USD)*	*Demand per $1,000 GDP (kgs)*
Angola	50,000	4.6	622	7.4
Cameroon	24,500	1.8	696	2.6
Cote d'Ivoire	42,000	3.0	763	3.9
Gabon	16,000	14.5	5,185	2.8
Ghana	40,000	2.3	371	6.3
Kenya	31,000	1.2	345	3.4
Nigeria	35,000	0.3	288	1.1
Senegal	75,000	8.8	606	14.5
South Africa	130,000	3.1	3,043	1.0
Tanzania	6,000	0.2	197	1.0
Zambia	10,000	1.1	376	3.0
Zimbabwe	7,000	0.6	686	0.9
Sub Saharan Africa (all countries)	**510,000**	**0.9**	**515**	**1.7**

Sources: *LPG*: WLPGA, IEA; *Population and GDP*: World Bank.

4.13 When state-owned Petroci entered the LPG business in 1994, it actually developed its own market without harming competition. While sales by existing marketers remained globally unchanged at their stable, long-standing level of 20,000 tons per year or so, Petroci actually created a new market within the untapped, albeit solvent, potential market. In just three years, sales had increased by 30 percent. Such development showed that:

- marketers sell whatever quantity is available; they are constrained (among others) by supply, not by demand;
- private sector marketers do not develop their activities as long as it is not profitable. In Cote d'Ivoire, the LPG administered price did not provide a positive operating margin until the recent price adjustment, thus leaving the private marketers' activity coasting without new investment;
- upside potential is important and not constrained by income (LPG prices were regulated and Petroci's rates were similar to that of other marketers); and
- new markets are still to be tapped. Although Petroci developed the traditional, 12-kg cylinder market, its new promising markets were for the 6-kg cylinders intended for lower income households (which is the leading market in Senegal as well) and the 45-kg cylinder dedicated to small businesses, with particular emphasis on the popular sidewalk restaurants to be found in hundreds in Abidjan's industrial and populous areas.

4.14 LPG demand in SSA is actually driven by supply constraints. This has been a long-standing issue. In those countries where a refinery operates, it generally is the only source of domestic supply. Production is limited by the refinery's size and technical LPG output ratio, which depends on its design and the quality of crude oil processed. LPG output from refineries has proved largely insufficient to meet growing demand, while landlocked countries and those without a refinery (i.e., the majority) can only rely on limited imports from neighboring countries through inadequate, costly transportation and storage facilities.

4.15 LPG imports are often constrained by high (distorted) import prices, the refinery's official or de facto monopoly and / or protection, limited receiving storage facilities, and procurement and transit procedures. As a result, only 5 percent of the LPG consumed in SSA is supplied through international trade, well below the corresponding figures for South America (21 percent) and Asia (50 percent).

4.16 In the near future however, availability of LPG from regional sources will no longer remain an issue. A study by Mackay Cons. projected that offshore gas production in Western and Eastern Africa was expected to soar from 5 bcm in 1997 to 12 bcm in 2000, an 140 percent increase in just three years, well above the 14 percent increase projected for the activity worldwide. Incremental LPG stripped from wet gas streams (such as Panthere in Cote d'Ivoire) should thus supplement in increasing proportion the LPG output extracted from associated gas in oil fields (such as N'kossa, Congo; Lion, Cote d'Ivoire; Alba, Equatorial Guinea). In addition, there is a large number of fields that are still dormant in almost every single oil country across SSA. Regional aggregate output in the Gulf of Guinea area from facilities completed or nearing completion was expected to reach 500,000 tons by the end of 1998.

Institutional Issues

4.17 Lifting supply constraints at the production level must be accompanied by parallel measures aiming at facilitating LPG trade throughout the region. Experience shows that (technical) supply bottlenecks are often compounded by institutional issues. Where institutional framework is inadequate, the organization of the industry and economic regulation are unlikely to develop incentives for the operators, which translates into lack of investment in essential infrastructure (receiving terminals, storage, bottling, and distribution facilities).

4.18 With regard the organization of the industry, LPG operation is generally carried out (but for a few exceptions), by private entities. However, bottlenecks do remain, often due to exclusive rights held by some operators such as refineries or bulk storage operators, translating into unfair conditions in accessing markets.

Pricing Issues. Are Subsidies an Option?

4.19 Bulk prices (ex-refinery or import prices) are often designed to protect the refineries, not the consumer. As a consequence, they distort end-user prices. They generally consist of high ex-refinery prices, based on Mediterranean prices for small spot cargoes, coupled with expensive freight established on the basis of small ships. They typically range from USD170 to up to USD800/ton. While such pricing formulae are appropriate, from an economic standpoint, in a scarce supply environment where the alternative to local supply is to import LPG from Europe or the Gulf, they are definitely out of line, however, in a situation where local supply is becoming abundant -- which is increasingly the case in the Gulf of Guinea sub-region.

4.20 Because of its high socio-political content and limited supply, LPG pricing is generally established and controlled by governments. While prices do have to be regulated as long as suppressed demand and structural dysfunctions remain, operating margins must be attractive enough to allow operators to invest and develop their activities. Once supply is no longer constrained and the organization of the industry is sound, price regulation is no longer required.

4.21 Over the long term, end-user prices must reflect the actual economic cost of the product. Subsidies may have helped develop the market initially (e.g., in Senegal), but wherever they might be required to help develop the LPG industry in a first time, they must remain temporary, explicit and transparent. Experience shows that:

- in many countries, LPG consumption has remained idle in spite of subsidies, because supply constraints, not weak demand, is the key issue;
- where subsidization policy was successful, subsidies created a heavy burden on the State's budget, which increased as LPG demand developed;
- in turn, the Government may try to recover part of the subsidies through reducing operators' margins, thus hampering industry development and creating shortage situations;
- without reducing bulk import cost through improved infrastructure and pricing structure, removing subsidies often present a certain political risk;
- although they are intended to help the poor, subsidies often miss the assigned target and do not help allocation of public money efficiently;
- subsidies develop smuggling; they may actually benefit consumers in neighboring countries rather than domestic consumers;
- they are counter-productive as they tend to create scarcity, which in turn translates into black market, smuggling, thus higher actual prices.

Developing Hubs to Increase Supply at Lower Cost

4.22 At local level, present and potential LPG demand exceed the capacity of existing refineries and local LPG-stripping plants. Thus, additional supply will have to be provided through international and regional trade. In addition to larger countries located along the seaboard, smaller consuming countries as well as landlocked countries and markets with no direct access to bulk supply require efficient, well-equipped intermediate levels of supply (storage, transportation) to keep costs as low as possible.

4.23 The economic cost of the LPG chain is very sensitive to the size of operation. Significant savings along the whole chain can be achieved through economies of scale by pooling requirements of neighboring countries and increasing the size of terminal and bulk storage facilities at suitable locations, thus allowing larger LPG cargoes to be delivered where LPG is imported, stored or traded. In turn, increasing the throughput reduces the unit cost of storage and handling and enables marketers to upscale bottling plants and streamline the marketing and distribution process.

4.24 Establishing such common carrier import terminals (hubs) implies some basic pre-requisites. It must enjoy good land / sea connections (spokes) to downstream markets, with easy access, reliable operation, and low costs. Then, the hub must operate in a sound institutional environment; being a natural monopoly (more than one hub in a single medium-size country is unlikely), it must be operated under a concession of regulated monopoly. It should be operated as a common carrier by an independent company, and its facilities should be open to all operators, to allow for promoting competition at downstream levels of the LPG chain (transportation, secondary storage, bottle filling and distribution). Open access implies that fees should be charged on a non-discriminatory basis to users with similar patterns. A good cooperative environment with neighboring countries is required to facilitate imports / re-exports, with particular emphasis on an efficient bureaucracy (namely customs) to speed up cross-border trade.

Toward New Regional Markets

4.25 Until now, due to limited local LPG supply, transfer prices were established on the basis of import parity prices in the region, including a reference FOB price in the nearest supply source outside the region (e.g., Mediterranean, NWE), and related international ocean freight. Due to limited markets and tight receiving facilities, freight was calculated on the basis of small cargoes, which led to very high landed costs. Developing hubs at suitable locations for countries joining together to co-operate in receiving, storing and handling cargo sizes of 2,500 to 3,000 tons would help freight rates from Mediterranean ports drop to less than USD 100/ton.

4.26 Furthermore, with the commissioning of new LPG production facilities linked to the development of gas (whether associated or not) in the region, local markets in Sub-Saharan Africa will benefit from competition in a surplus product scenario. First, LPG at production sites should be available at lower FOB prices, based on the CIF price on traditional markets, such as Brazil, or at major hubs (Mediterranean, Bahrain, Caribbean) minus ocean freight. Second, closeness of regional hubs to production facilities should keep regional freight rates at more reasonable levels, probably as low as USD30 to 50/ton, where increased receiving and storage facilities allow the use of larger LPG tankers. As a result, development of this new regional market would enable the countries in the region to reduce the delivered cost of LPG (at end user's) to a level where subsidies would no longer be necessary. As an example, of particular relevance for the LPG industry is the project aiming at reducing gas flaring at the Bombay High offshore oil (and associated gas) field. This project, primarily dedicated to mitigating the emissions of greenhouse gases, enabled India to increase by 15 percent the quantity of LPG available for domestic consumption. Given the size of the Indian market and the importance of the then suppressed LPG demand, adding 0.5 million tons per year on the supply side brought a most appreciated relief to both LPG dealers and consumers, and made easier the participation of the private sector in the downstream activities.

Conclusions

4.27 The LPG market in Sub-Saharan Africa is at a turning point: a significant suppressed demand can be met from increased regional supply sources in a cost effective manner, provided that:

- the reform of the institutional and regulatory framework that was initiated in the upstream segment (level playing field and PSCs) and was instrumental in boosting exploration and the development of large and medium-size oil and gas discoveries, be pursued in the mid- and downstream segments to bring economic efficiency in the refining and distribution of oil products, including LPG;
- operators are given incentives to develop their activities, in particular, through rational price structures based on real economic costs;
- subsidies are removed as the landed cost of LPG is progressively reduced thanks to scale economies through the development of hubs and the emergence of regional (or sub-regional) LPG reference prices; the only way for the LPG industry to develop in a sustainable, non distorted manner is to do it without draining public finance;
- price regulation is progressively lifted as supply constraints fade, and fair competitive procedures govern the access of the operators to the market, although some regulation is still required until market can be fully opened; and
- access to hubs, i.e., receiving, bulk storage, handling and sending facilities is made open to all operators on a non discriminatory basis.

5

Institutional And Regulatory Matters For Gas Downstream Activities

Why is a new Regulatory Framework Needed?

5.1 In SSA, the contractual conditions underlying gas exploration and production (upstream activities) are generally set out in the regulations governing the oil sector. In view of very recent developments in the gas industry, however, issues related to the transmission, distribution and marketing of gas (downstream activities) are not governed by specific regulations. Instead, regulation is carried out on a case-by-case basis, according to project contracts (regulation by contract). As long as the gas industry involves a very limited number of players, such a system does not impede the exploitation and marketing of resources. But the situation may be changing very swiftly, as it is the case, for instance, in Cote d'Ivoire. The growth of the gas industry has notably seen the arrival of new sources of supply and new producers -- in search of new markets, as one might expect. The resulting increase in options, with regard to gas production, transmission and consumption, could lead to tensions or to the emergence of practices that may be prejudicial to healthy business development. These practices may emanate from the operators themselves (cartels, abuse of monopoly situation, predatory conduct) or from the political authorities (interference in day-to-day management or inappropriate pricing policy). Whatever their nature, such practices are prejudicial to the optimum allocation of resources, and thus to economic efficiency. In establishing specific rules for downstream activities -- rules which apply to all those involved (whether operator, consumer or government) -- the aim is to reduce the risk that such practices may emerge, by establishing a level playing field for the various activities.

5.2 In essence, therefore, the regulatory framework has a dual objective: to protect consumers against the possibility of monopolistic practices on the part of operators, and to encourage investment by offering operators the assurance of a clear, lasting institutional framework that eliminates non-commercial risks. The framework does not in any way seek to define a nation's strategic planning or energy policy. These areas are, and will remain, the exclusive prerogatives of the government. Because the regulatory framework is part of the nation's institutional structure, its design, implementation and reinforcement are the affairs of government. Its goals, its structure and its content, as well as the tasks and the working methods assigned to the authority that will be responsible for its creation and implementation, will, from the outset, be the responsibility of the executive and legislative powers, that is to say of the political authorities. In this respect, the decision to create a new regulatory framework must be made clearly within the context of government strategy.

5.3 The fundamental guidelines and principles of the new framework, once approved, will be given definitive form in the «Gas Code», which must comprise three bodies of regulations : (a) a basic law, which defines the major principles of the regulations, with respect to competition and pricing policy, and which is complemented by a series of decrees and / or acts governing its implementation; (b) a model act (whether law or decree) governing the legal relationship between the authority granting the concession and the concessionaires; and (c) a law that sets out the tasks, nature and working methods of the authority responsible for implementing the Code and ensuring its lawful application by the regulated operators and by the government.

5.4 More specifically, the Gas Code should govern the following:

- the organization and structure of the gas industry,
- the organization of competition among operators and of market access,
- operators' legal framework, that is the relationship between the authority granting the concession and the concessionaires,
- price-setting, price monitoring and price adjustments over time, that is the principles governing payment of operators,
- the exercise of legal power to resolve conflicts between parties involved in gas-industry activities,
- the nature, tasks and working methods of the regulatory authority (the Regulator) responsible for implementing the Gas Code.

Organization and Structure. Competition and Market Access

5.5 It is intended that gas regulations should endure. They should cover not only prevailing circumstances, i.e., the de facto transmission and marketing of gas, but also circumstances that may exist in the future, whether in terms of activities already envisaged, such as the distribution and export of gas, or those that are technically feasible, such as gas imports or storage. With regard to transmission, the «hybrid» solution may be the best option. Under this system, the operator is granted a concession for a specific location and a specific period of time, and there is no one single transmission concession for the nation as a whole. The operator conveys gas on behalf of others (whether sellers or buyers), and is paid in the form of a toll, rather like a freeway operator. He may also buy gas for his own account, and sell it on to his own customers (large consumers, distributors). These two activities, transmission and marketing, are carried out in an equitable manner, and pricing and accounting mechanisms are open to the public. Excess capacity at the gas pipeline is made available to other buyers or sellers, who may borrow the pipeline at a non-discriminatory price. The operator may not refuse to convey gas in his pipeline, as long as it is not over capacity.

5.6 The distributor will enjoy a monopoly, in terms of physical location and time, over the area for which he has been granted a concession. This monopoly applies to the distribution of gas, but not to its marketing. A seller (producer or transporter) may sell gas directly to his clients, but may not construct and exploit a pipeline for his own account or on behalf of his clients. He must operate through the distributor, who pays him a non-discriminatory toll, while the distributor, for his part, may not refuse to distribute gas on behalf of others as long as his network is not threatened. Similarly, he may not refuse to construct a pipeline, for which he will receive a toll based upon real construction and operating costs.

5.7 In a largely decentralized organization such as that proposed, operators should be as independent as possible, and should not violate the territory of another operator. In this way, conflicts of interest and anti-competitive practices will be avoided. For example, producers or buyers (or groups of buyers) may not have a controlling interest in a transporter. If this were the case, they might enjoy an unfair advantage over other parties, with respect to conveying the gas. Similarly, a transporter controlled (for example) by a producer might be required to adhere to the producer's strategy, rather than pursue the logical path of any transporter, which is to build up his network and thus expand his market.

Economic Regulation

5.8 Regulation should apply to those components of the gas chain that are natural monopolies. This covers gas transmission and distribution (for oil products, including LPG, it might include bulk storage where a monopoly, or a tight oligopoly is in place at country level). Conversely, the price of gas as a commodity usually does not require regulation as gas has to compete with other energy products and doers not enjoy any monopoly situation. As for most other goods and services, price regulation is thus achieved by the market itself and prices should be negotiated between the seller and the customer. For this reason, the AGI recommends that transmission and distribution tariffs, not end-user prices, be regulated.

5.9 Tariff policy (which includes both structure and levels) is the affair of the operators, who set their tariffs according to their expected investments, costs and resources. But tariff policy should controlled and approved by the regulating authority (the Regulator), who, in particular, sets a cap on the tariffs proposed by the operators in order to avoid the abuse of monopoly situation. Indeed, this is among the Regulator's main tasks. In addition to the examination of the operator's development and resource plans, one of the main criteria for setting tariffs is the way in which tariff regulation is carried out. There are several ways of regulating tariffs, and the underlying principles and regulatory techniques are similar for the transmission and distribution of gas.

5.10 In the case of a new gas industry, the best model is that of regulation by cost of service. Tariffs are fixed in such a way as to enable users to obtain the service they need at a reasonable cost, and to enable investors to recover their costs and earn an acceptable return in terms of the capital they have invested or the risk they have incurred in constructing or taking on a gas pipeline or distribution network. Tariffs are determined according to the expected gas output levels and volumes to be conveyed by the network in question (control of resources), and the overall cost of the activity (cost control). Also included in the calculation are interest charges on debt repayments, operating costs, tax charges, expected costs for renovation and expansion, and capital amounts to be repaid to investors.

Compatibility with Government Policy

5.11 Whenever a concession is being sought, the Regulator reviews the professional and financial credentials of the candidates and advises the Department responsible for granting the concession (wherever the Regulator itself is not the responsible authority). The Regulator studies the operator's development and resource plans, and gives its assessment of those plans – an assessment which may include rejection of the plans or a request that they be modified. The Regulator will also ensure that the plans submitted for its review are compatible with the level of gas resources (national or potentially imported) and that the plans do not conflict with government strategy on the exploitation of the nation's national resources (or with their conservation and harmonization, wherever these are relevant concerns). This latter point is particularly important with respect to gas-export projects.

Regulatory Authority (the Regulator)

5.12 Within the classic institutional framework (in SSA, i.e. based on public ownership), the government, as the embodiment of political power, plays a three-fold role – a policy role (by defining long-term strategies and goals and by controlling the selection of senior staff); a financial role (by controlling – and sometimes setting – the budget, setting prices, and granting concessions); and a technical role (by defining standards for the use of machinery and equipment). The major problem with this type of framework is that it makes no clear distinction between political concerns, on the one hand, and business concerns, on the other, nor does it distinguish between the execution of tasks and its own controlling function. It is legitimate that a company operating in an area involving the notion of public service should adhere to strategic guidelines defined upstream at a political level. But the political intervention should cease at that stage, so that day-to-day management may be performed on an independent basis.

5.13 The best way to resolve these problems is to entrust the non-strategic aspects of regulation to the most independent entity possible. This is particularly important when it comes to setting and monitoring both pricing policy and the prices themselves. The role of the Regulator is to implement the Gas Code and ensure that it is applied. Although there is no typical model to be found in a majority of those countries that have this kind of Regulator, there is a certain consensus as to how powers and responsibilities should be shared out between political institutions and the Regulator. One can clearly discern a «core» of functions generally assumed by the Regulator, which operates as a sort of common denominator for the majority (see Table 5.1).

5.14 For reasons that concern both economic efficiency (economies of scale) and the increasing interaction between the various energy sectors and between the players involved in them, it would be more effective if the Regulator were to be given power over a particular sector or sectors. In this way, it could govern not only downstream gas activities, but also the electricity sub-sector, and even the distribution of water and certain aspects of oil-product distribution. In the areas of gas and electricity, in particular, the existence of a single Regulator will ensure that decisions taken with regard to projects involving two sub-sectors, as is the case with electricity production via gas and co-generation, will be balanced and consistent. It will also make it possible to take an overall view of the sector and operate effectively, by respecting the strategic choices of the political authorities.

5.15 In order that it can perform smoothly the tasks conferred upon it by the political authorities, the Regulator must be as independent (autonomous) as possible, and its level of independence must be guaranteed under the law that brings it into force. Ideally, it should keep an equal distance from the various economic players concerned: operators, consumers and Government. In practice, its level of independence will be defined in three ways:

5.16 ***Nomination of members***. These should be selected by the political authorities (the executive body and the legislative body, and even the legal body if it is endowed with the power of arbitration). This mode of selection is not only inevitable, but logical in the sense that the creation of this institution is a political choice. Members will be nominated for a set period of time, during which they may not be removed. Their professional qualifications must be a major factor in their nomination.

5.17 ***Relationship to political power.*** In this context, many configurations are possible, ranging from a simple ministerial department to an Agency that is largely independent. Between these two extremes, three levels of independence might be envisaged :

- an independent regulatory body, functioning either within a general ministerial department not affiliated to any particular sector, such as the Planning or Economics Ministry, or directly under the authority of the Prime Minister,
- an Agency endowed with a certain degree of autonomy, with one or several Departments taking part in its decision-making processes,
- an Agency endowed with considerable decision-making autonomy, but which provides for an external appeals procedure (for example a legal or government body).

5.18 ***Means of implementation***. The number of employees engaged in the regulatory function must remain small, but staff must be well qualified. They must include people with technical skills, who are able to understand the practical problems experienced by operators, people with the economic and financial expertise necessary for the implementation of economic regulations, and people with the administrative and legal skills required to cope with the other areas and with the political authorities. In order to strengthen the independence of the Regulator, and so that they are not a burden on the public purse, the financial resources required should be separate from the general State budget (a specific tax levied on operators, who are empowered to pass it on to consumers).

Table 5.1 – Areas to be Regulated and Powers of Regulator

Regulated areas	*Powers*
Sector strategic planning	Political power (the Regulator may also play a consultative role, providing suggestions and advice)
Public investment	
Restructuring of sector, privatization operations	
Investment Code	
Fiscal policy and policy on subsidies	
Granting of concessions and licenses	Both political (frequently) or regulatory power can be considered
Definition of technical and financial standards for Regulatory operators seeking to carry out a regulated activity	
Evaluation of candidates' qualifications according to established norms	
Monitoring of concession and license grants; monitoring of how initial development plans are being reflected in practice	
Economic regulation (fixing, implementation and adjustment of prices; approval and monitoring of operators' investments and resource plans)	
Monitoring of structure and health of operators' assets	
Monitoring of respect for rules of competition and market access	
Design and implementation of operational norms and standards in the fields of technology, security and the environment	The technical Departments concerned or the Regulator
Conflict arbitration	Regulator (preferably) or administrative court.
Appeal (if appeals procedure provided by Gas Code)	Compatibility with constitutional rules and organization of legal authority Another legal body (administrative court) or another Department.

Joint UNDP/World Bank

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	***Activity/Report Title***	***Date***	***Number***
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercilizing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
	Africa Gas Initiative – Main Report: Volume I	02/01	240/01
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
	Africa Gas Initiative – Angola: Volume II	02/01	240/01
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cameroon	Africa Gas Initiative – Cameroon: Volume III	02/01	240/01
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB

Region/Country	***Activity/Report Title***	***Date***	***Number***
Congo	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95
	Africa Gas Initiative – Côte d'Ivoire: Volume V	02/01	240/01
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
	Africa Gas Initiative – Gabon: Volume VI	02/01	240/01
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83

Region/Country	*Activity/Report Title*	*Date*	*Number*
Malawi	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	--
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84

Region/Country	***Activity/Report Title***	***Date***	***Number***
Sudan	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--
	Rural Electrification Study	03/00	228/00

Region/Country	Activity/Report Title	Date	Number
	EAST ASIA AND PACIFIC (EAP)		
Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/999
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94

Region/Country	*Activity/Report Title*	*Date*	*Number*
Vietnam	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97

Region/Country	*Activity/Report Title*	*Date*	*Number*
Central and Eastern Europe	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00

MIDDLE EAST AND NORTH AFRICA (MNA)

Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN (LAC)

LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97

Region/Country	*Activity/Report Title*	*Date*	*Number*
LAC Regional	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88

Region/Country	*Activity/Report Title*	*Date*	*Number*
Jamaica	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

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	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon		

Region/Country	*Activity/Report Title*	*Date*	*Number*
Global	Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99
	A Review of the Renewable Energy Activities of the UNDP/ World Bank Energy Sector Management Assistance Programme 1993 to 1998	11/99	223/99
	Energy, Transportation and Environment: Policy Options for Environmental Improvement	12/99	224/99
	Privatization, Competition and Regulation in the British Electricity Industry, With Implications for Developing Countries	02/00	226/00
	Reducing the Cost of Grid Extension for Rural Electrification	02/00	227/00
	Undeveloped Oil and Gas Fields in the Industrializing World	02/01	239/01

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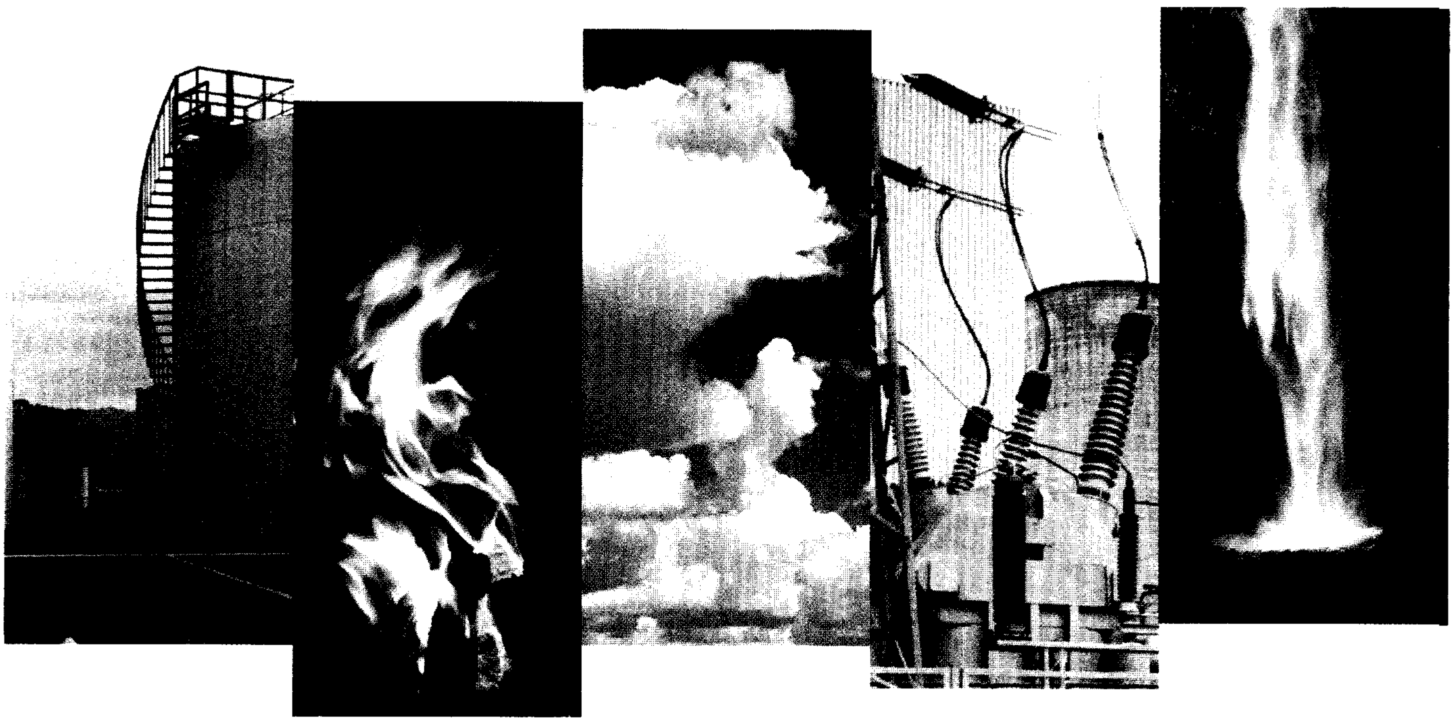

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