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PERU'S DOWNSTREAM NATURAL GAS SECTOR: A PRELIMINARY ASSESSMENT



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ABBREVIATIONS AND ACRONYMS

APLA	<i>Asociación Petroquímica Latinoamericana</i> (Latin American Petrochemical Association)
BOOT	Build-Own-Operate-Transfer Contract
CC	Combined-Cycle Gas Thermal Power Plant
CFE	Comisión Federal de Electricidad (México)
CNG	Compressed Natural Gas
COFIDE	<i>Corporación Financiera de Desarrollo</i> (Development Financing Corporation)
COFIGAS	COFIDE program to finance conversions to natural gas
DGE – MEM	<i>Dirección General de Electricidad – Ministerio de Energía y Minas</i> (General Bureau of Electricity – Ministry of Energy and Mines)
DGH – MEM	<i>Dirección General de Hidrocarburos – Ministerio de Energía y Minas</i> (General Bureau of Hydrocarbons – Ministry of Energy and Mines)
ENAPU	National Ports Company of Peru
GDP	Gross Domestic Product
GoP	Government of Peru
GRP	<i>Garantía de la Red Principal</i> (Principal Network Guarantee)
GSA Bol Brasil	Gas Sales Agreement – Bolivia/Brazil
GTL	Gas to Liquids
HH	Henry Hub
IDB	Inter-American Development Bank
IRR	Internal Rate of Return
LGN	Natural Gas Liquids
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
MEM	Ministry of Energy and Mines
NG	Natural gas
NGV	Natural Gas for Vehicles
NGL	Natural Gas Liquids
OSINERGMIN	Supervisory Agency for Investments in Energy and Mining (<i>Organismo Supervisor de la Inversión en Energía y Minería</i>)
Perupetro	Perupetro S.A. (<i>Empresa Estatal de Derecho Privado</i>)
PLNG	Perú LNG
PPA	Power Purchase Agreement
PRE	<i>Plan Referencial de Electricidad</i> (Electricity Reference Plan - Ministry of Energy and Mines)
PRH	<i>Plan Referencial de Hidrocarburos</i> (Hydrocarbon Reference Plan - Ministry of Energy and Mines)
ProInversión	<i>Agencia de Promoción de la Inversión Privada – Perú</i> (Private Investment Promotion Agency – Peru)
PV	Present Value

PYME	Small and Medium Industry
SCI	GNV Intelligent Load System
SEIN	<i>Sistema Eléctrico Interconectado Nacional</i> (National Interconnected Electricity System)
TGP	<i>Transportadora de Gas del Perú</i> (Gas Transportation Company of Peru)
U.S.	United States of America
US\$	United States dollar
WTI	West Texas Intermediate

UNITS OF MEASUREMENT

Bbl	barrels
Bbl/d	barrels per day
Bcf	billion cubic feet
Btu	British thermal unit
cf	Cubic feet
km	kilometers
kW	kilowatt
m ³	cubic meters
m ³ GN/kWh	cubic meters of natural gas per kilowatt-hour
m ³ -mes	cubic meters per month
MM	million
MMCFD	million cubic feet per day
SCFD	standard cubic feet per day
MW	megawatt = 10 ³ Kilowatt
MWh	megawatt-hour
T or Ton	tons
T/year	tons per year
Tcf	trillion cubic feet = 10 ¹² cubic feet
US\$/Bbl	United States dollars per barrel
US\$/kW	United States dollars per kilowatt-hour
US\$/m ³ /km	United States dollars per cubic meter per kilometer
US\$/MMBtu	United States dollars per million Btu

Executive Summary

A. Introduction

1. **Since the first gas from Peru’s Camisea Field began flowing in 2004, natural gas has successfully helped to diversify the country’s energy matrix and provided an important new source of domestic energy for the country’s rapid economic development.** To spur the development of the country’s nascent natural gas industry, the Government established promotional policies including preferential prices for key domestic users, especially for the electric power sector. While these policies helped attract private sector investment in the gas sector, they also created barriers to both upstream and downstream development of natural gas. There are concerns that the preferential policies for natural gas are hindering the broader development of Peru’s energy industry, including investment in the country’s hydroelectric resources. As the country seeks to further expand the use of natural gas, there are questions about how to continue to attract private sector investment while at the same time achieving national energy and development goals.

2. **This study assesses the natural gas market in Peru.** The original focus of the study was on the identification of potential new markets for natural gas in Peru, looking beyond the power sector, and specifically at expanding gas use among industrial, residential and commercial, transportation, and petrochemical users. In the process of evaluating the downstream market, the study identified opportunities for meeting the Government’s aspirational goals with respect to energy and natural gas development, including the efficient use of natural gas in the power and other sectors, strengthening and coordinating national energy planning for the gas sector, infrastructure development and the prospects for the decentralization of the natural gas market in Peru, and the potential of natural gas pricing reforms for the promotion of hydroelectricity and other renewable energy sources. Environmental and social considerations related to the development of the Peruvian gas sector are not part of the scope of this study. Such considerations are, however, essential to the sound development of the gas industry in Peru and will need to be taken into account in specific implementation strategies.

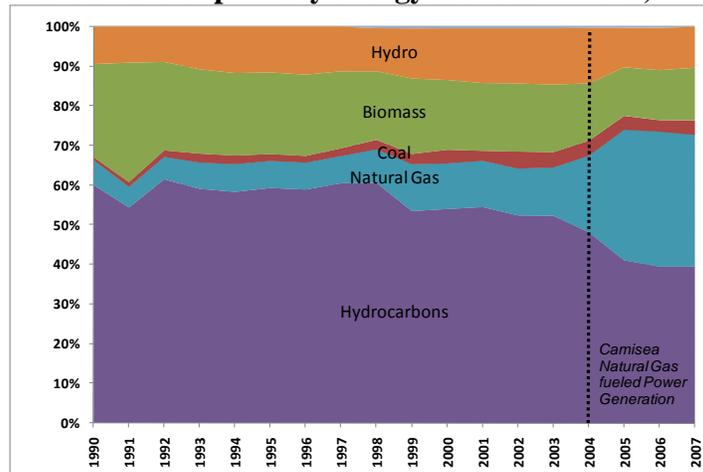
B. The Natural Gas Sector in Peru

3. **The discovery and development of the Camisea Gas Field has provided Peru with a major new source of energy that has helped satisfy the country’s growing demand for energy.** In August 2004, the first gas from Camisea reached the Lima-Callao area, following nearly twenty years since the discovery of the field. The development of natural gas from Camisea was accompanied by a policy of low natural gas prices for consumers. This policy was meant to speed up the adoption of natural gas by private sector users. Price stability was achieved through the use of a price indexing

formula and by the establishment of a ceiling on price increases.¹ As a direct consequence of this policy, and relative to the large increase in international petroleum prices, the price of natural gas from Camisea for the domestic market has remained considerably below international energy indexes.

4. **Development of natural gas has led to a more diversified energy matrix in a very short time.** Prior to the development of Camisea, Peru’s energy matrix was based primarily on petroleum followed by hydroelectricity (figure ES1). The share of natural gas in Peru’s energy matrix increased substantially from 7 percent in 2002 to an estimated 28 percent in 2008. At the same time, the relative shares of hydrocarbons and biomass dropped in the energy matrix. From the perspective of diversification, the natural gas policies in Peru have been very effective in expanding the share of gas and reducing the share of petroleum. An important question is whether natural gas policies have also negatively affected the country’s plans to increase the share of hydroelectricity and led to the inefficient use of gas by the power sector.

Figure ES1: Share of primary energy sources in Peru, 1990-2007



Source: MEM

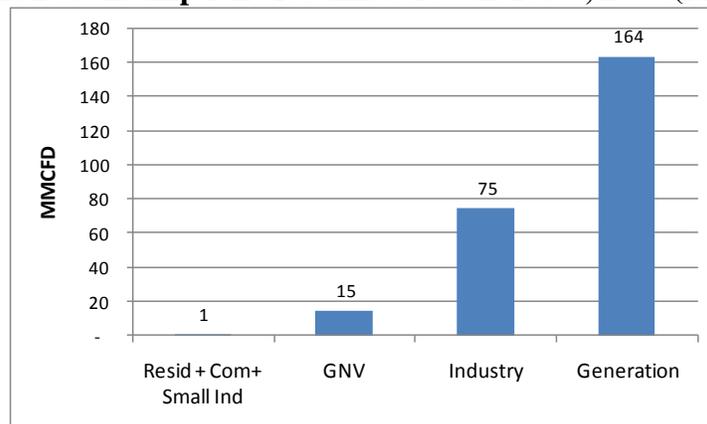
5. **The principal domestic consumer of natural gas in Peru has been the power sector.** The majority of natural gas has supplied four electric power plants in and around Lima-Callao: Ventanilla, Santa Rosa, Chilca, and Kallpa. The use of natural gas for power generation started modestly in 2004, providing fuel for a single generating plant (Ventanilla), with a total consumption of 360 million cubic feet (MMCF). The consumption of natural gas for power generation grew very fast, reaching almost 46 billion cubic feet (bcf) in 2007, representing a daily average of 126 million cubic feet per day (MMCFD). The demand in 2008 for power generation was around 164 MMCFD, and for other uses about 76 MMCFD, totaling 240 MMCFD. The estimated demand for Camisea gas for electric power over the next five years is about 235 MMCFD (2012),

¹ Increases in natural gas prices in the first five years of the contract were limited to 5 percent per annum or the equivalent of the percentage increase in international petroleum prices, whichever was lower. After this initial five-year period, annual increases in natural gas prices were simply limited to the increase in the price of petroleum.

which corresponds to between 700 MW to 800 MW of additional gas-fired generating capacity. Once the full planned capacity of the principal TGP pipeline is available by 2010, the Ministry of Energy and Mines (MEM) has estimated that between 2,200 MW and a maximum of 2,800 MW of new natural gas-fired power capacity could be installed using the reserves of natural gas from Camisea (assuming all gas goes to power generation). The power sector consumes the majority of natural gas from Camisea, accounting for 65 percent of the total consumption from the field (figure ES2). Power generation and industrial users have been the largest consumers of natural gas and also the largest beneficiaries of the government’s low gas price policy.

6. **The consumption of natural gas in other sectors of the economy has been modest.** Gas use for transportation (*natural gas for vehicles*, NGV) increased during 2008, but overall consumption remains small and available only in the Lima-Callao area. Gas for residential, commercial, and small industrial consumers has remained low in part due to government subsidies provided for liquefied petroleum gas (LPG), the primary substitute, and due to relatively large upfront investments needed to supply piped natural gas to these consumers. Liquid petroleum products (diesel, residual and fuel oil) have continued to play an important role as back-up fuel sources for electricity generation.

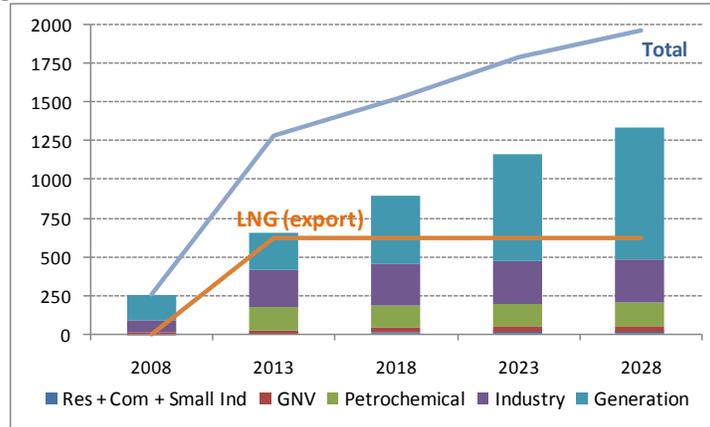
Figure ES2: Consumption of Camisea Natural Gas, 2008 (MMCFD)²



Source: MEM

² The volumes shown in the graph correspond to available data for January-March 2008; for the case of power generation, the *Estudio de Capacidades Contratadas* was used.

Figure ES3: Forecast of Camisea Gas Demand (MMCFD)



Source: MEM Reference Plan (2008-2028) – Hydro-Thermal Scenario.

7. **The GoP has formulated both “centralized” and “decentralized” scenarios for the expansion of gas use.** Under MEM’s “Reference Plan (2008-2028),” a *Centralized Scenario* assumes that the main consumer sector, electricity generation in open-cycle plants, would be concentrated near Lima-Callao.³ In such a case, Camisea production would reach approximately 1,962 MMCFD in 20 years, with a growth rate of 11 percent per year (figure ES3). This demand would be distributed as follows: 1,337 MMCFD for the domestic market and 625 MMCFD for liquefied natural gas (LNG) exports. In this plan, the Lima-Callao region’s demand would account for 72 percent of total gas consumption.

8. As an alternative to the centralized scenario, government authorities are evaluating a scenario that *decentralizes* the increase in generation from Lima to the country’s Northern and Southern regions. Rather than receiving electricity from the Lima region via electric transmission lines, each region would essentially be self-sufficient in their electricity supply through the transport of gas to regional electric power plants. This *Decentralized Scenario* assumes the development of two new gas pipelines: (a) Lima-Chimbote, and (b) Camisea-Ilo. These pipelines would facilitate the development of major gas consumption in other parts of the country, including non-power sector consumers. Among the plans under this scenario are the development of a petrochemical industry and potential other large-scale demands in the south: Arequipa, Ilo, Moquegua, and Tacna.

C. Potential New Markets for Natural Gas

9. **One of the main tasks of the study was to evaluate potential new markets for natural gas in Peru.** In addition to the four current sectors that are consuming gas in Peru – (1) electric power, (2) industry, (3) transportation, and (4) residential and commercial, – there is also potential for establishing a petrochemical industry based on natural gas. Given the dominant nature of the power sector both historically and in the future, the potential to increase the efficiency in the use of natural gas for power

³ Gas-powered thermal capacity in the Lima-Callao region would increase by 1,690 megawatts (MW), from 1,190 MW in 2007 to 2,880 ME in 2015.

generation is discussed in subsequent sections, while the analysis of potential new markets for natural gas is discussed first.

i. Industry

10. **The current demand for gas by the industrial sector is concentrated in a handful of large and medium size enterprises connected through the distribution network in the urban areas.** Due to the current configuration of the gas supply network, industrial consumption is concentrated in Lima-Callao. The concentration of demand in only a few individual consumers (such as power plants) is even more evident in other regions of the country that have access to natural gas.

11. **There is currently a wide gap between the cost of natural gas and other fuels used in industry.** Given the increase in international petroleum prices that has occurred in the past five years, the cost advantage of natural gas is a key factor facilitating the sustained growth of industrial gas demand. The study concludes that the value of natural gas (based on substitute fuels) for the industrial sector (excluding petrochemicals) in Peru varies between US\$7/MMBtu to US\$10/MMBtu. These values are much higher than the current promotional price of US\$2.4/MMBtu, showing the large cost advantage of gas for those industrial consumers⁴ that can obtain it. The prospect of large numbers of new industrial gas consumers provides encouragement to plans for the construction of regional gas pipelines. The industrial sector, not including the petrochemical sector, will be a significant driver of the domestic demand for gas, which is estimated under the Government's reference plan to reach 290 MMCFD in 20 years, which would amount to around 22 percent of the country's total natural gas consumption.

ii. Transport

12. A unique feature of the market for natural gas for vehicles (NGV) is that the demand typically develops first in large urban centers and then extends to other regions with the extension of gas transport infrastructure. If the demand for gas continues to be concentrated in the Lima-Callao region (the "centralized scenario"), it is likely that the demand for NGV would also be concentrated in this area. However, **since the Lima-Callao region accounts for nearly two-thirds of the country's automobiles, even limiting the use of NGV to this region could theoretically supply a significant portion of the country's vehicle fleet.** Another important factor in the development of the NGV market is the large cost to consumers that is needed for converting vehicles from liquid fuels to gas, or of maintaining flexibility by making them bi-fuel.⁵ Since the arrival of gas in Lima-Callao, there has been a rapid growth in transportation demand for natural gas, with about 35,000 vehicles⁶ in mid-2008 using NGV, or about 5 percent of the automobile fleet in Lima-Callao. According to MEM, by 2033 consumption of natural

⁴ Industry uses natural gas as both a source of energy and as a raw material in manufacturing.

⁵ For retrofits, the most costly elements are the tank and conversion kit. For new dedicated natural gas vehicles, the initial capital cost is the relevant factor.

⁶ In mid-2008, the natural gas industry predicted that the number of natural gas vehicles in Peru would total 60,000 by the end of 2008.

gas for transport is estimated to be 38.5 MMCFD, compared to about 15 MMCFD in 2008. The number of gas refueling stations would increase from 32 in mid-2008 to 185. The experience drawn from studies conducted for the regions of Ayacucho, Arequipa, Ica, and Junín shows that the potential growth of NGV would be modest compared to Lima-Callao.

13. There are several factors indicating that the official forecasts are achievable:⁷ (a) the financial benefits of switching from liquids to gas are positive, due to the pricing of natural gas compared to substitute fuels; (b) the mechanisms to finance conversions in Peru have been effective; and (c) the profitability of natural gas service stations in the initial stage of development is high, which encourages people to open them, but this in turn causes profits to erode over time. However, price advantages for natural gas for vehicles compared to gasoline are often justified in the initial stages of development in order to overcome the resistance of potential consumers to convert their vehicles, and to provide the necessary encouragement for expanding the supply of NGV. But these incentives, especially those incorporated in NGV pricing, should decrease over time as the market develops and as other disadvantages – such as limited availability – disappear. There are also typically significant air quality and health benefits that can be gained by converting vehicles (and especially conventional diesel buses) to natural gas. The new Metropolitan bus system will be first in LAC to be powered by natural gas, which produces lower emissions of local pollutants and CO₂ than conventional transport fuels such as diesel. Ultimately, the extent of usage of NGV will be limited by the expansion of the natural gas pipeline system, which in turn will depend on the level of reserves.

iii. Residential and commercial

14. The experience of gas distribution in Lima-Callao shows that one of the barriers to higher penetration is the low overall consumption of cooking fuels and heating needs—the dominant residential use of natural gas in Peru – and the fact that LPG prices are also low. Although socially and environmentally significant, residential and commercial markets for gas are likely to be small relative to the overall demand for gas in Peru. Forecasts reflect this in all regions.⁸ The decision to convert to piped natural gas means that the user must amortize a fairly large investment for the connection and the internal installation costs against a relatively low overall volume of consumption. The limited availability of consumer financing for these installations has reduced the demand for residential conversions.

15. Some progress has been made in overcoming the installation cost barrier.⁹ Based on a new tariff regulation adopted in 2007, the cost of the service connection and pipes is

⁷ Currently, the investment made in converting the vehicle from gasoline to NGV is recovered in less than one year for a private vehicle, while the time is reduced to three to four months for a taxi that is driven an average of 200 km per day (OSINERGMIN 2008).

⁸ Despite the substitution of types of energy used by these segments for cooking and heating, they show a high economic benefit, releasing more costly resources (liquefied petroleum gas [LPG], kerosene, electricity).

⁹ Unlike the previous contractor for distribution which did not have obligations to increase coverage or expand service, Calidda does have such obligations in its contract.

financed by the lender (the distribution company Calidda) through the payment of a fixed charge of US\$2.50/month, which is added to the user's bill. In addition, the company has promoted a policy to finance the purchase of gas-consuming equipment and controls, which consists of extending the financing period from five to eight years, with the payment of a US\$3.20/month fee. **In this context, the gas distribution company in Callao and Lima estimates that in a period of five years (2008–12), the number of users will increase from 12,000 at present¹⁰ to 100,000.** According to MEM, in 25 years there could be 325,000 residential customers in the Lima-Callao region, with an estimated consumption of 7.2 MMCFD (0.5 percent of the country's total natural gas demand). This forecast is very likely to be achieved and it could be supplied under any of the scenarios of natural gas reserves.

iv. Petrochemicals

16. Peru currently lacks a petrochemical industry, and instead imports all petrochemical products.¹¹ The potential of significant natural gas resources in the country has raised the possibility of establishing a domestic petrochemical industry, though the international financial crisis and reduced prices for petrochemicals has reduced the attractiveness of building Greenfield plants in 2009-10. The GoP's role in facilitating the development by private investors would be critical in the following aspects: (1) definition of the location of petrochemical complexes, and the cost and responsibility to invest in infrastructure facilities needed by the industrial development; (2) policies for the use of infrastructure that supports the complex: ports, gas pipelines, water, electricity, housing, roads;¹² (3) definition of objectives and priorities of supporting petrochemical development; and (4) regulations/incentives that define technical features of the plants,¹³ and the establishment of priority uses and prices for the petrochemical industry.

17. An analysis of the net back price of gas in the petrochemical sector is between US\$3.0/MMBtu to US\$7.0/MMBtu for urea prices between US\$400/ton and US\$500/ton (the average international price for urea in 2009 was only US\$250/ton, yielding a netback price of gas of US\$1.7/MMBtu). This means that only in the case that Peru confirms the availability of significant and low-cost natural gas reserves, would the development of a second or third phase¹⁴ of a petrochemical industry be a good investment for the private sector. One of the key unresolved issues for petrochemical development overall in Peru is

¹⁰ Estimate as of end-2008.

¹¹ In 2006, nearly 1.5 million tons of petrochemical products were imported with an estimated value of US\$1 billion.

¹² It is acknowledged that there is a lack of infrastructure in each of these areas in the potential sites for petrochemical development.

¹³ For example, whether or not used plants could be installed

¹⁴ Three phases have been planned for the development of the petrochemical industry in Peru: (Phase 1) Methane, urea, ammonia nitrate, and phosphate fertilizer production. The contract has been mostly negotiated by the GSA and the site will probably be Marcona. (Phase 2) Ethane production. Studies are under development to define price schemes and regional pipeline routings, as well as the location of the plant. (Phase 3) Ethylene and polyethylene production. While the first phase is concentrated largely on the domestic market, both the second, and particularly the third phases would require selling the output on both regional and international markets, raising issues of competition and requiring higher levels of reserves.

who will be responsible for strategic oversight and investment in related infrastructure facilities. In the case of the planned nitrogen fertilizer plant at Marcona, the National Ports Company of Peru (ENAPU) has been commissioned to conduct a study, but there has been no decision over who would be responsible for investments in roads, hospitals, schools, and other facilities, and how these investments would be financed.

18. The development of petrochemical industries based on ethane has so far had no active bidding processes underway in Peru.¹⁵ There has also been no agreement on a likely location of the ethane-based olefin-polyolefin complex, information that is needed to determine the netback cost of the ethane. Given significant economies of scale, ethane development could be undertaken only with a significant level of proven natural gas reserves, and probably as a second phase in the development of a petrochemical industry in Peru. Because Peru cannot absorb the entire production volume of such a plant, the demand for products needs to be analyzed in the context of a global, or at least a very large regional, market. Petrochemical production from Peru would therefore compete with many low-cost international producers.

D. Issues and Options for Improving Peru's Downstream Gas Sector

19. There are several key factors that will affect the development of the downstream natural gas market in Peru, including the level of natural gas reserves. Regardless of the ultimate level of reserves, the country can improve the efficiency of gas use and the expansion of gas infrastructure through a combination of policy reform measures and coordinated government planning.

i. Natural gas reserves

20. **The amount of recoverable natural gas reserves in Peru will be a fundamental factor for determining the new uses of natural gas in the country.** The gas reserves in Peru have been the object of much speculation over the past several years due to inconsistent reporting of the potential size of the country's gas reserves. According to information released by MEM's Direcccion de Hidrocarburos (DCH), Peru has between 9 and 11 Tcf of proven reserves. Geologists, operating companies and Perupetro estimate that potential resources¹⁶ may be as much 50 Tcf. Given that investment plans for gas infrastructure development and for final users is dependent on the availability of gas reserves, there is an urgent need for the GoP to increase the reliability and quality of reserve estimates. This would help establish a clear basis for the development of the natural gas market and the associated large investments that need to be made in production, transmission, and end-user facilities. The GoP could provide more certainty

¹⁵ A study is being conducted on ethane recovery and logistics, which would include possible locations for an olefin hub that, according to sources consulted, would be completed in a few months.

¹⁶ "Resources" are the total amount of gas that are in the ground, while reserves are the fraction that can be extracted which is determined by geology, technical capacities, and costs.

to potential investors by conducting an audit of different natural gas reserve estimates and making the results available to industry and the general public.

21. Under a high reserve scenario, the range of potential new uses of gas is obviously greater, including development of gas for both domestic consumption and significant gas for export. If large reserves are available, big consumers of natural gas include not only additional power plants, but petrochemicals, the ethane industry and even fertilizers as feasible options. Large reserves could also facilitate widespread investment for small and medium-size users, including for residential, commercial and small industrial, and transport demands. Large reserves would also strengthen the case for decentralization, by allowing the development of large anchor demands such as power and petrochemicals.

22. Under a low reserve scenario, priority will likely be given to the domestic market, including power generation, and a limited number of industrial users, as well as small transport and residential demands. Lower levels of reserves would also reinforce the centralized natural gas program concentrated in Lima-Callao. If only limited reserves are available, the country and policymakers need to define the type of alternative uses that they want to encourage and how to prioritize the use of gas for the domestic market.

ii. Energy efficiency potential

23. **Peru's natural gas generation portfolio presents tremendous opportunities for conservation and energy efficiency improvements due to the prevalence of numerous open-cycle power plants.** Between 2004 and 2008, new natural gas-fired electric power capacity, primarily less-costly but also less-efficient open-cycle technology, expanded rapidly in Peru. The abundant supply of cheap natural gas and a relatively uncongested pipeline facilitated this expansion. Calculations show that the natural gas price at which combined-cycle generation becomes competitive with open-cycle generation is at least US\$0.50/MMBtu, and perhaps as much as US\$1.00/MMBtu, higher than the current price of gas delivered to power generating plants in Peru.¹⁷ Table ES1 shows natural gas consumption and efficiency rates for the power sector in Peru, where all but one of the power plants utilizes open-cycle technology; TG Ventanilla Gas is the only combined-cycle plant in Peru.

24. The efficiency of an open-cycle plant is on average 40 percent less than a similarly-sized combined-cycle plant. Had all natural gas power plants used combined-cycle technology as of 2008, gas consumption would have been 28 percent lower, representing a potential savings of around 18 percent of the total natural gas consumed in Peru. The GoP estimates that closing open cycles would contribute between 800 MW and 900 MW, based on the same amount of natural gas used currently – this is nearly two years of current generation capacity needs.

¹⁷ US\$3.10/MMBtu is an estimate of the natural gas price (at the power plant) that makes an investor indifferent between open and closed-cycle technologies. Given pipeline transportation costs of US\$0.85/MMBtu, the break-even wellhead price of natural gas would be about US\$2.25/MMBtu. This analysis indicates that the US\$1.50/MMBtu promotional price for Camisea natural gas is a full \$0.75/MMBtu below the price structure that would stimulate investment in closed-cycle technology.

Table ES1: Natural Gas Consumption and Fuel Efficiency in Power Generation

Power Unit	2007			2008		
	Electricity GWh	Natural Gas MCF	Efficiency Rate KWh/MCF	Electricity GWh	Natural Gas MCF	Efficiency Rate KWh/MCF
<i>Malacas TG1</i>	23.8	364,312	65.3	29.5	470,678	62.6
<i>Malacas TG2</i>	37.2	587,839	63.3	49.7	765,754	64.9
<i>TG2 Aguaytía</i>	560.9	7,043,247	79.6	587.1	7,244,926	81.0
<i>TG Santa Rosa UTI -Gas</i>	125.0	1,541,176	81.1	256.5	3,133,356	81.9
<i>TG1 Aguaytía</i>	580.7	6,988,746	83.1	636.6	7,648,949	83.2
<i>Malacas TGN4</i>	533.9	5,987,685	89.2	606.0	6,766,561	89.6
<i>TG Santa Rosa WTG -Gas</i>	296.1	3,313,512	89.3	171.2	1,826,562	93.7
<i>Kallpa</i>	279.9	2,749,180	101.8	987.6	9,746,546	101.3
<i>Chilca TG2</i>	632.9	5,778,758	109.5	1,272.0	12,094,508	105.2
<i>Chilca TG1</i>	1,323.6	12,401,683	106.7	1,288.9	12,022,305	107.2
<i>TG Ventanilla Gas</i>	2,916.1	20,075,619	145.3	3,433.6	22,494,283	152.6
Overall	7,309.9	66,831,756	109.4	9,318.7	84,214,428	110.7

Source: COES (2008).

iii. Integrated energy planning

25. **There is enormous potential for improving the performance of the natural gas industry through integrated energy planning together with other sectors.** The regulator OSINERGMIN and the Ministry of Mines and Energy have typically operated independently of each other with respect to the private sector, which has been the major investor in the development of Peru's hydrocarbon and other infrastructure sectors. To increase private sector investment in the natural gas sector, and to simultaneously promote national goals, the Government needs to actively strengthen its role in the following areas: (i) natural gas sector planning and the availability of basic information (for instance, geological and reserve data); (ii) pricing policy and adequate regulations to guide private sector development; (iii) clear and consistent rules for awarding project concessions, and (iv) regulations to promote the use of efficient technologies (e.g., specifying efficiency criteria for power plants).

26. Domestic demand for natural gas should be calculated in a rigorous and integrated manner, taking into account the electricity sector as the main consumer, but also the demands by other consumers, including industrial and petrochemical sectors, aggregated residential and commercial consumers, and natural gas for transport. The results of the planning exercise could be used by the Government to define more precisely the type of regulatory measures needed to scale up the use of natural gas in the country without compromising the security of supply of both internal and external markets. In addition to planning tools, the complexity and relative newness of the natural gas industry in Peru underscore the importance of having adequate technical capacity to provide strategic planning for the natural gas sector within the overall energy sector. Currently, the Government and the private sector lack expertise on natural gas strategy and regulatory matters. Efforts for capacity building in the gas sector are also important in light of Peru's ongoing development of the natural gas sector for both domestic and international markets.

iv. Expanding natural gas transport infrastructure

27. **The lack of basic natural gas transport infrastructure is hindering further expansion of the natural gas market in Peru.** Natural gas in Peru is transported from the Camisea Gas Field to the Ica-Pisco area and from there to Lima by a main pipeline system. The increased consumption of natural gas has been higher than expected, and the pipeline system has faced increasing congestion. During 2008, the transport capacity of the system reached 400 MMCFD, which exceeds its maximum nameplate capacity. It is expected that by 2010 the compression installations will be expanded to provide a maximum capacity of 450 MMCFD. Different scenarios show that in 20 years, domestic demand (excluding volumes for Peru LNG) will at least quadruple from a current volume of 315 MMCFD to approximately 1,337 MMCFD. There is an urgent need to expand the current system capacity with new gas pipelines to meet these levels of demand.

28. **The construction of the pipeline from Camisea to Lima was facilitated by a novel financial guarantee mechanism that could be effectively utilized for new pipeline development.** A surcharge for the pipeline has been included in the bills of electricity consumers in Peru under the *Garantía de la Red Principal* (Principal Network Guarantee),¹⁸ which compensates for a portion of the investment cost of the gas pipeline.¹⁹ The surcharge is eliminated once the capacity is fully contracted. It would appear that some sort of guarantee will be needed to attract the private sector for new pipeline construction, given the uncertainty of new demands in Peru.

29. **The Government's decentralization plan will require additional investment – both for pipelines and other infrastructure – that may not be immediately forthcoming from the private sector.** In addition, some infrastructure investments will need to be made upfront to facilitate firm gas off-take contracts. Under the decentralization program, the plan is to create new anchor demands (i.e., power generation, petrochemicals) in other parts of the country to benefit other cities and provinces through the use of natural gas. An interesting mechanism that could be explored to finance this investment is the reinvestment of revenues associated with an increase in the price of natural gas. Future negotiations with private investors need to have a clear understanding of the type and amount of investment needed to support the creation of anchor demands and associated infrastructure.

v. Natural gas pricing

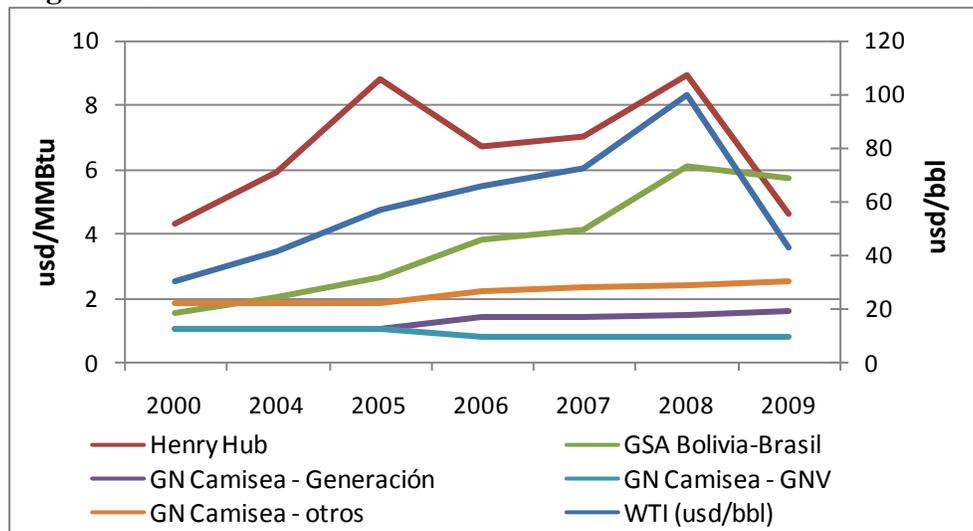
30. **Average prices of natural gas in Peru have been substantially below those in other parts of Latin America over the past five years.** There have been large

¹⁸ Studies for the Camisea gas pipeline indicated unattractively high transport tariffs, due to the expected low demand during initial years of gas production. Investors in the pipeline required the Government to guarantee a minimum capacity usage/payment during the first years of operation. MEM and the regulator designed the GRP as a payment guarantee.

¹⁹ For example, in 2007, the gas transport tariff to pay for the GRP was US\$1.381 per megawatt-month, which is equivalent to approximately US0.245 cents of per kilowatt-hour. The GRP was reaching its termination; therefore, its tariff was reduced considerably in 2008 (about one-fifth of the 2007 GRP tariff).

fluctuations in international gas prices over the past several years, and international gas prices during parts of 2009 have not been entirely out of line with natural gas prices in Peru (figure ES4). Nonetheless, since 2004, average domestic prices for natural gas from Camisea have been considerably below the reference prices of other countries in the region. At an international petroleum price (WTI) of 70 US\$/Bbl,²⁰ the price of the natural gas for Brazil and Argentina is around 4 to 6 US\$/MMBtu respectively, prices that are two to three times those of natural gas from Camisea. As a result of Peru's natural gas policies, domestic gas prices have been relatively uncorrelated with the rise of international natural gas prices (Henry Hub) and with international oil prices (West Texas Intermediate, WTI). As natural gas and petroleum prices increased in international markets during 2004-2008, the relative price of natural gas in Peru fell. This benefitted all those consumers of liquid fuels that were able to switch to natural gas, as well as electricity consumers who benefitted from lower electricity prices.

Figure ES4: Indicative International and Domestic Natural Gas Prices



Source: MEM

31. **At \$1.50/MMBtu, the price of natural gas from Camisea for power generation is among the lowest in the world and has led, among other things, to the construction of inefficient natural gas plants.** Domestic prices in Peru are regulated by OSINERGMIN (natural gas cap prices, flat transportation tariffs), with export prices freely negotiated between producers and buyers. The efficiency in the use of natural gas in Peru could be improved by a pricing formula linked to international price references and the willingness-to-pay by different types of consumers.

32. **The ability of natural gas demand to expand also depends heavily on the pricing policy for substitute fuels, including LPG and diesel.** Consumption subsidies provided to those that already have access to gas (either LPG or piped natural gas) does little to improve overall access rates. In this regard, a program to subsidize fuel

²⁰ The US Department of Energy has forecast the international price of oil at 60 US\$/Bbl for 2009, 80 US\$/Bbl for 2010, and 100 US\$/Bbl in 2013.

consumption for low-income consumers (using the databases of existing social assistance programs) may be preferable to a general subsidy for LPG, which in practice also provides subsidies to medium- and high-income consumers. In the residential sector, a factor that decreases the incentive for connection for piped natural gas is that the price of LPG has a very high subsidy component (30 percent), complicating any incentive policy for access and connection to the natural gas network. Because gas network coverage is limited, the government could consider alternative solutions that do not rely entirely on LPG subsidies. Cash transfer programs for those regions in which networked natural gas supply is not available can be set up in a way that minimizes errors of exclusion for those who cannot afford the full price of LPG, but that also limits errors of inclusion for those high-income consumers.

E. Conclusions

33. **Peru's rapid growth in the last decade has triggered a greater demand for energy.** During this time, the GoP simultaneously pursued the development of a domestic gas market with the objective of diversifying Peru's energy sources. Peru has been very successful in diversifying its energy supply through the production of natural gas from Camisea. The natural gas industry in Peru is young. Great progress has been made in the sector during the initial five years of production, including successful diversification of the country's energy supply. New policies and a more active role by the Government are needed in order for the natural gas sector to achieve the Government's development, efficiency, and equity objectives.

34. **Expanding the use of gas in Peru will require increased clarity on the availability of sufficient natural gas reserves to justify the investments in infrastructure and in plant and equipment by downstream users.** Additional information provided by the GoP on reserves and development plans would, for example, likely help to attract new investment to the gas sector. This in turn would help clarify the expansion of natural gas use beyond current uses. The availability of gas transmission and distribution infrastructure also figures prominently in the expansion of natural gas demand.

35. **Industrial uses of natural gas are an important market in Peru and are a logical addition to the large-scale power sector demands.** Given the environmental, efficiency, and convenience benefits of natural gas, industrial users (especially those that require a clean fuel for electricity and heat) will be willing to pay netback values (related to the opportunity cost of other fuels) for natural gas.

36. **The expansion of consumption of natural gas by residential and commercial consumers has environmental and convenience benefits but faces two primary challenges: upfront financing for consumers and subsidies for LPG.** The first challenge is to overcome the lack of financing for the initial hookup for piped natural gas and for the conversion of appliances, for which there has been progress recently in Lima-Callao. A second challenge is the existence of significant subsidies for LPG, especially

for middle and high-income consumers, which has reduced the incentive for the expansion of piped natural gas.

37. **Natural gas is often justified in the transport sector as an economical way of reducing air pollution associated with vehicular traffic.** It would appear that the Government's estimates of potential natural gas demand by the transport sector are completely achievable and perhaps conservative, even if the transport market is only limited to Lima-Callao. Natural gas pricing is not the only policy for promoting the adoption of natural gas vehicles. Environmental legislation, tax incentives, and other measures to promote the adoption of natural gas vehicles can be important for expanding transport demand for gas.

38. **Petrochemical investment beyond the current first phase of fertilizer production will require large gas reserves and large investments.** In addition, the issue of investment in the construction of infrastructure remains unresolved. While certainly representative of an "anchor" demand, it does not appear that basic petrochemicals such as ethylene or even urea are the highest-valued use of natural gas in Peru at the current time. The prices of petrochemical products in the international market are currently depressed and there are numerous low-cost producers internationally with whom Peru would need to compete to become a petrochemical producer. Also, since the market for Peru's petrochemicals would need to extend beyond the domestic market, import-substitution is an insufficient objective.

39. **Improving the efficiency in the use of natural gas by the power sector will require either an increase in the price of natural gas, or the adoption of higher technical specifications of power plant equipment.** As noted, nearly one-fifth of Peru's current natural gas consumption could be saved if combined-cycle technology was universal. Alternatively, the equivalent of nearly two years of new power generating capacity in Peru could be provided through the use of combined-cycle instead of open-cycle technology.

40. **An integrated long term plan for the electricity and natural gas sectors is needed and could be developed and implemented through the creation of a governmental unit with the technical know-how to link the objectives of the government with those of private investors.** Such a unit's initial task could be to develop policies and regulations that are consistent with the GoP's overall objectives for hydrocarbons, electricity, and renewable energy.

41. **Decentralization of the natural gas and electric power systems, while providing a more balanced industrial and power development and improved energy security, will require significant investment in infrastructure that may not be immediately forthcoming from the private sector given the range of perceived risks (inadequate demand, regulatory uncertainty).** A key factor for private investment will be to have clear reserve and demand estimations and a gas transportation plan for the medium- and long-term supply. An appropriate tariff scheme and financial structure to

stimulate the development of transport infrastructure, with or without decentralization, is an important challenge that remains, and will require significant government attention.

42. **Present prices and regulatory rules for natural gas are hindering the Government's objective of promoting the development of hydroelectricity and other renewable energy technologies.** To level the playing field between natural gas and hydroelectric plants will require a price of gas between 3.50 and 4.00 US\$/MMBtu, compared to the current price of around 1.50/MMBtu. Secondly, to provide a market signal for more efficiency combined-cycle power plants will require an increase in current natural gas prices of between 0.50 and 1.00 US\$/MMBtu (i.e., to 2.0 to 2.5 US\$/MMBtu). If domestic prices continue to be far below international market prices, there is little incentive for private producers to supply the domestic market. There are also likely to be continuing conflicts between domestic users that are paying different prices for natural gas.

I. Introduction

1. The Government of Peru (GoP) considers the development of the natural gas sector as an opportunity for the country to gain a more balanced energy portfolio for the production of electricity and for other energy needs such as heat and motive power. The discovery of the Camisea gas field allowed Peru to support its growing energy demand with domestic energy resources. In developing the natural gas industry, the GoP began an important initiative for the energy sector that was accompanied by a series of sectoral policies. These included incentives to a broad set of consumers to have access to natural gas, with the goal of achieving a more balanced regional and sectoral development of the energy sector.

2. The GoP established a number of goals to guide the development of the natural gas sector within the broader energy sector. One of the principal objectives for the GoP in developing the natural gas industry has been to diversify the sources of energy for the country, and in the process, reduce the reliance on imported petroleum. Other near- and medium-term goals for the energy and gas sector include: (i) achieving roughly equal contributions from petroleum, natural gas, and renewable energy resources, including hydroelectricity, in the energy matrix; (ii) increasing the efficiency of natural gas-fired electricity generation by closing “open-cycle” plants and promoting the installation of combined-cycle facilities; (iii) expanding the coverage and utilization of natural gas through a process of decentralization whereby gas would be transported and distributed beyond the current major consumption centers of Lima-Callao, and (iv) increasing the allocation of natural gas to the domestic market in future exploration and production contracts.

3. To assist in these tasks, the GoP requested the World Bank to evaluate strategies for the sound development of the domestic natural gas market. As an initial step, the World Bank was asked to identify and characterize the potential market size, and the related institutional and regulatory frameworks that would be needed for the future development of the natural gas market in Peru. The study was to provide the foundations for a more ambitious study to set out a strategic program of policy options and investments to effectively utilize Peru’s natural gas resources. The study was to also contribute to a more active policy dialogue between the Bank and the GoP on energy issues, complementing other ongoing activities by the World Bank in the country’s infrastructure sector. Environmental and social considerations related to the development of the Peruvian gas sector are not part of the scope of this study. Such considerations are, however, essential to the sound development of the gas industry in Peru and will need to be taken into account in specific implementation strategies.

4. This report is divided into the five chapters. Following a description in this Chapter I of the context in which this study was prepared, Chapter II present a history of the natural gas sector and the Government of Peru’s policy objectives to increase the use of natural gas in the domestic economy. Chapter III presents potential new markets for natural gas within the present context of the natural gas industry and the Peruvian

economy. Chapter IV describes findings, issues, and options for improving Peru's downstream natural gas sector, including a discussion of the consistency between the Government's objectives and its policies for the sector. Chapter V sets out the conclusions of the study.

II. The Natural Gas Sector in Peru

5. One of the most important infrastructure development projects in Peru over the past decade has been the construction of facilities for the exploration, development, transport and distribution of natural gas from the Camisea field. The development of the natural gas industry provided a strategic option for Peru's energy policy, allowing a major increase in domestic energy resources, and changing the patterns of supply and demand in the energy sector. In 2005, the first year of natural gas production, the use of natural gas in power plants, industry, transport and households resulted in a decline in the share of liquid petroleum fuels in Peru's energy matrix by 9 percent compared to 2004.

6. The oil and gas sectors in Peru were fundamentally reformed in the mid-1990s. Law No. 26221 (1996) established a new institutional framework and is the basis for current investments in the sector. The main features of this Law, which allowed a significant increase of investments in oil and gas exploration, are the following:

- The Ministry of Energy and Mines (MEM) is responsible for sector policies, and through the *Dirección General de Hidrocarburos* the MEM exercises the responsibility for guiding the sector and establishing regulations. The government is to progressively retire from productive and commercial activities in the sector. A new contracting agency, Perupetro, was designated to promote investments in exploration and production (E&P), and to sign and monitor E&P contracts.
- A privatization strategy was adopted separating Petroperú business units. Upstream operations were transferred to private operators. Petroperú kept control of almost half of the country's refining capacity, the Transandean pipeline, and a few gasoline stations, mainly outside Lima.
- The Exploration and Production (E&P) contract was radically changed, separating royalties from income taxes. Royalties were fixed at an initial rate of 12 percent (a ratio of accumulated revenues to accumulated disbursements).
- Compliance with existing regulations (*fiscalization*) became the task of a new independent institution, Organismo Supervisor de la Inversión en Energía y Minería (OSINERGMIN), which reports to the Prime Minister's office.

The Camisea project

7. Camisea consists of several natural gas fields located in the Ucayali basin of southeastern Peru. The Camisea gas fields (named after the village of Camisea on the Lower Urubamba River where the fields are located) include Block 88 (for which operating agreements, transportation and distribution were signed in 2000 to supply primarily the domestic market, starting with Lima) and Block 56, awarded in 2004 to a consortium of companies (which a priori would be devoted to projects for export). The reserves of Block 88 comprise two deposits (Saint Martin and Cashiriari) discovered by Shell in 1984 (see box 1). An international consortium has developed the upstream portion of Camisea, with Pluspetrol as the project operator. Different private and government analysts have estimated that Block 88 contains between 8.8 and 11 Tcf of

proven plus probable (P2) natural gas reserves and 482 million barrels of associated natural gas liquids (NGLs).²¹

Box 1. A Brief History of Camisea's Development

In 1986-87 the Government of Peru negotiated an operating agreement with Shell, which ultimately failed to close due to a number of disagreements, some of them financial in nature. Negotiations resumed eight years later and in May 1996 the Government of Peru signed a new agreement valued at US\$2.5 billion with a consortium led by Shell/Mobil for the development of the Camisea Gas Fields. To facilitate the investment, the Government provided the consortium with a series of incentives, including general sales tax and custom duties benefits, to increase the profitability of the project. In July 1998, the consortium announced the suspension of the project, citing the lack of domestic markets for gas sales, discrepancies over the price of gas for electricity generation, and unmet demands by the consortium for the vertical integration of the project (including exploration, development, transport and distribution), and to allow exports to Brazil, which had not been included in the original agreement.

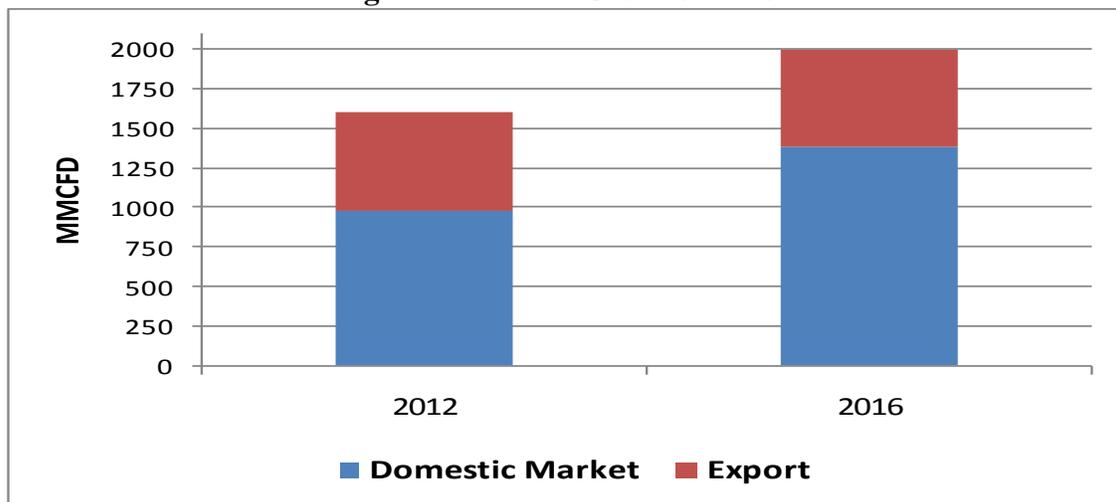
The legacy of Shell in Camisea included sunk investments of around US\$400 million and a set of environmental standards and social safeguards. During the first year of exploration by Shell, the sensitive environmental nature of the Camisea area was highlighted. Shell also experienced environmental and social setbacks in Nigeria and the North Sea during this time. As a result, Shell pledged to make a second effort to enforce environmental and social standards at Camisea including an upstream work plan that would minimize impacts from road construction, provide a generous health plan for employees, and include extensive consultations both locally and internationally. These measures helped to establish a new definition of environment and social safeguards for other companies operating in the region.

In February 2000, the Government of Peru launched a new bidding process. A consortium initially composed of Pluspetrol (Argentina), Hunt Oil (United States), SK Corporation (South Korea) and Tecpetrol (Argentina) won the contract for the development of Block 88 and subsequently also for Block 56, for a period of forty years. An initial upstream investment of US\$400 million was offered for the field facilities and an estimated total investment for the term of the contract of US\$1.6 billion. Under this contract, Peru would receive approximately US\$1.9 billion in taxes and US\$3.5 billion in royalties. In late 2009, the Camisea partners committed to make substantial additional investments in facilities to support increased production in the face of increased domestic demand. In October 2000, a transportation and distribution contract for natural gas and by-products was awarded to the consortium Transportadora de Gas del Peru (TGP), led by the Argentinean company Techint. TGP offered an investment of US\$1.45 billion in an agreement of 33 years' duration. Besides Techint, other consortium companies included Sonatrach (Algeria), Graña y Montero (Peru), SK Corporation (South Korea), Hunt Oil (United States) and Pluspetrol (Argentina). In May 2002, the Government awarded a concession contract for the distribution of natural gas through the network of pipes in the city of Lima-Callao to the Belgian company Tractebel, which created the distribution company *Gas Natural de Lima and Callao*. Under the contract, Tractebel was to make an investment of around US\$200 million. In August 2004, twenty years after Camisea was discovered, the first gas from Camisea arrived in Lima.

²¹ Official reserves were reported by the Ministry of Energy at the end of 2007 to be 11 TCF. Recent reports from a consulting company working for the Ministry stated that Camisea proven reserves are 8.8 TCF. The reserve analysis figures need to be confirmed before new natural gas demand projects could be committed.

8. The natural gas industry in Peru is young, with production from Camisea beginning only in August 2004. The initial production capacity at Camisea was 450 million cubic feet per day (MMCFD) of natural gas and 34,000 barrels per day (Bbl/d) of liquids. Output capacity is expected to increase steadily, as drilling continues on Camisea's Block 56, adjacent to Block 88. TGP constructed and operates parallel natural gas and LNG pipelines that carry Camisea production to Lima and to a fractionation plant in Paracas. Camisea natural gas production today is 300 MMCFD. A total of 35,000 Bbl/d of oil liquids are produced, including liquefied petroleum gas (LPG) and natural naphtha. The remaining dry gas, given limited transport and consumption levels, is reinjected into the gas fields. With the start-up of LPG production from the fields, it is expected that production for the domestic and external markets will total 1,600 MMCFD by 2012.²² Without considering ethane production, the production of liquids will increase to 95,000 Bbl/d when maximum natural gas production is achieved.²³ The estimates of production in this study were made only on the basis of MEM reported proven reserves, and they resulted in a production capacity by 2016 of around 2,000 MMCFD (figure 1). If the demand of 620 MMCFD for the export of LNG is subtracted, there would be about 1,337 MMCFD of natural gas available for various domestic and/or external market uses over the next 22 years. However, as noted, the estimates regarding reserves and production capacity have been changing, which affect the analysis of the potential to develop domestic markets set out in this report (see, e.g., discussion below in Chapter IV on relevance of reserves).

Figure 1: Natural Gas Production



Source: Raul Garcia and Associates calculations

²² Information provided by the Peru LNG consortium.

²³ The investment made to develop gas fields, in forecasted figures from 2000 to 2009, amounts to US\$2,200 MM in the Camisea zone. The production of liquids will continue due to high prices of petroleum contributing to the bulk of revenue upstream.

9. Gas transportation from Camisea, which together with gas production poses important environmental and social issues (see box 2),²⁴ is provided by a single pipeline (owned by TGP) to Lurin, 60 km south of Lima. From Lurin to Lima-Callao (the terminal station) the transport of gas is provided by Calidda, the gas distribution company for

Box 2. Environmental and social considerations for natural gas transport and distribution

Investments in natural gas production, transport, and use pose major environmental and social issues. Among the common impacts associated with gas transportation specifically are: habitat loss, the introduction of invasive species; human and domestic animal intrusions; erosion and landslides; wetlands and stream deterioration and water quality alterations; and modifications of indigenous peoples' and local communities' ways of life. This report does not address the specific environmental and social issues associated with natural gas development in Peru, however, a wealth of good environmental and social practices for the oil, gas, and mining sector have been developed worldwide, including in Peru.

One project in Latin America that provides useful environmental and social lessons is the Bolivia-Brazil gas pipeline project. Among the lessons are:

- Environmental impact assessments must be standardized across regions to facilitate comparison, and planning should be a continuous process applied in all project stages.
- Mapping of sensitive areas should be prepared before construction begins, and the environmental management cycle during the operational phase must emphasize identification and monitoring of geographically challenging areas along the right-of-way (ROW).
- Construction contracts should contain incentives for compliance with environmental safeguards as well as penalties for non-compliance, and the timely sequencing of construction activities can minimize the effects from erosion and slope instability.
- Social and security considerations must receive as much attention as environmental concerns.
- Maintain the "law of consultation" – consult early and consult often.
- Continuous documentary information (films/ photos) of existing conditions along the ROW is indispensable to monitor and evaluate impacts.
- Training of project personnel and affected community members is a key element of the Environmental Management Plan and requires adequate resources.

In sum, it is possible for well-designed infrastructure projects to minimize the degradation of natural habitats and the loss of biodiversity and thorough Environmental and Social Assessments are the foundation of successful environmental and social outcomes. Early involvement of stakeholders has been shown to improve project design, operation, and management, and successful compensation and restoration measures can be achieved if and when impacts are identified during project implementation. Large-scale projects such as gas transmission systems can also facilitate institutional strengthening and restructuring and training and education programs are critical.

Source: Juan D. Quintero, "Mainstreaming Conservation in Infrastructure Projects, Case Studies from Latin America," World Bank, 2007.

Lima. There is also a pipeline section from the terminal station in Callao to Ventanilla (northern part of Lima), where a major thermal plant of the same name is located. There are three other power plants using Camisea gas: Santa Rosa (located in downtown Lima),

²⁴ Environmental and social issues related to the development of gas fields, pipelines and other related infrastructure are important issues, but fall beyond the purview of this initial study.

and the Chilca and Kallpa plants, located in Chilca, 70 kilometers south of Lima. The Camisea pipeline has different sections along its route with decreasing diameters and capacities. The initial section of the pipeline (about 211-km), extending from the gas field to the end of the forested area, has a maximum capacity of 1,200 MMCFD. The second section of 297-km in the Andes area has a maximum capacity of 450 MMCFD. The third section (226-km) up to the city gate in the coastal area has a capacity of 400 MMCFD, and the pipeline section of 60 km from the city gate to the terminal station in Callao has a capacity of 200 MMCFD. The pipeline of 7-km that supplies gas to the Ventanilla power plant has a maximum capacity of 150 MMCFD. The actual compression installations of the transport pipeline are not sufficient to allow the use of the second and third sections of the pipeline at their maximum capacities. The present estimated capacities of these sections are 250 MMCFD and 200 MMCFD, respectively. Without upgrades, there is a high possibility of interruptions of gas supply during peak hours to the thermal plants in the Lima area.

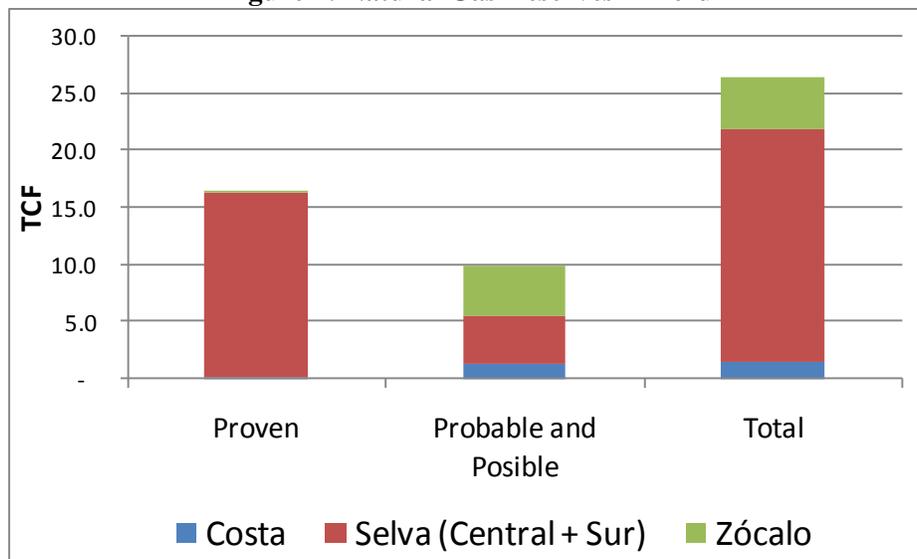
10. Estimates of power demand for Camisea gas indicate an 80 percent increase to about 235 MMCFD by 2012, which corresponds to between 700 MW to 800 MW of additional capacity of gas-fired electric power. Camisea natural gas use for electricity generation started modestly, providing until the end of 2004 the fuel requirements of a single generating plant (Ventanilla), with a total consumption of 360 MMCF. The power generation consumption grew very fast, reaching almost 46,000 MMCF in 2007, representing a daily average of 125.6 MMCFD. As mentioned, the current capacities of the last sections of the pipeline are beginning to create a bottleneck for the supply of gas. The expected demand in 2008 for power generation was 164 MMCFD, and for other uses about 76 MMCFD, totaling 240 MMCFD, greater than the present capacity of the coastal section and practically at the limit of the capacity of the Andean section. Once the full capacity of the Camisea pipeline is available by 2010, MEM has estimated that between 2,200 MW and a maximum of 2,800 MW of new natural-gas-fired thermal generation could be installed based on natural gas from Camisea allocated for internal use (and discounting other uses besides power generation).

Other natural gas fields

11. There is considerable uncertainty with respect to the amount of Peru's proven natural gas reserves. MEM reported proven natural gas reserves of 11.9 trillion cubic feet (Tcf) at the end of 2007 (the most recent available official Annual of Reserves Estimates made in 2005 and 2009 by Gaffney & Cline and Associates on behalf of Pluspetrol for the Camisea blocks only suggest proven reserves at between 6.97 and 8.79 Tcf. In January 2010, MEM announced that recoverable reserves (a different classification methodology than proven reserves) had risen to 13 Tcf. In addition, MEM announced that it had engaged a further independent audit of reserves by Netherland, Sewell and Associates, the results of which it expects in the next official Annual of Reserves. In 2006, the country produced and consumed 63 billion cubic feet (Bcf) of natural gas,

about 13 percent higher than the previous year. Official information published by MEM²⁵ stated that there were another 4.2 Tcf in probable and possible reserves in the Selva area (this area includes Peru’s Central Selva-Aguaytía and Southern Selva). In addition, in the areas of the Coast and the Zócalo (Paracas) there are 0.5 Tcf of proven reserves and another 6.0 Tcf of probable and possible reserves. A significant potential for future discoveries is also inferred. In the area of Gran Camisea, there are geological indications that reserves could total 50 Tcf,²⁶ with a high probability of success in terms of exploratory wells.²⁷ Besides Camisea, the largest concentrations of Peru’s natural gas production includes the Aguaytia Gas Field (Maple Gas) in central Peru, Block X (Petrobras) in the northwest region, and Block Z-2B (Petro-Tech), located off the northwest coast. In 2008, Repsol-YPF announced a new find in Block 57 and in late 2009, President García announced additional finds by Petrobras in Block 58, both near the Camisea project. BPZ Energy is developing the Corvina natural gas project in the offshore Block Z-1 in northwest Peru, with the intention of constructing an integrated gas-to-power facility that will include a subsea pipeline, and a 160 MW power plant. As an indication of the size of Peru’s natural gas reserves, there have also been discussions of eventually exporting natural gas to southern Ecuador.

Figure 2: Natural Gas Reserves in Peru



Source: OSINERGMIN and MEM (*Libro Anual de Reservas 2006*).

²⁵ According to the *Libro Anual de Reservas (Annual Book of Reserves)* published as of December 31, 2006, by MIN, there are another 4.15 TCF of probable and possible reserves, under the category of “Not Operated,” but with no mention of their location. These have not been included in this report.

²⁶ See *Petroleum Economist* magazine archive, June 2008 (www.petroleum-economist.com). Exploration and Production, “Peru: More LNG Considered as Bid Round Launches.” This information was confirmed at meetings held in Lima by geologists of petroleum companies and Perupetro itself.

²⁷ The interest shown by upstream activity has led the GoP to issue 80 new exploration permits in a period of two years. In the latest round of contracting 22 block bids, 17 have had qualified bidders.

Peru liquefied natural gas (LNG) project

12. Given the reserve expectations, one of the original underlying motivations for developing Camisea was to develop natural gas for domestic consumption, but also for export purposes.

13. In 2007, Peru LNG signed contracts with TGP for transportation of gas through the rainforest segment of TGP pipeline and in the same year awarded a contract to Techint for the construction of a 250-mile pipeline that will connect the LNG terminal to the TGP pipeline. In late 2007 and early 2008 a consortium of lenders including the Inter-American Development Bank (IDB), the International Finance Corporation (IFC) of the World Bank Group, the Export-Import Bank of the United States, the Export-Import Bank of Korea, SACE S.p.A. of Italy, and a number of commercial banks signed US\$2.05 billion of debt facilities for the US\$3.8bn Peru LNG project. Repsol-YPF, a member of the Peru LNG consortium, purchased rights to the entire output of the facility. In late 2007, Repsol concluded a contract with CFE, Mexico's state-owned power company, to supply the Manzanillo LNG regasification terminal in Colima, along Mexico's Pacific coast. According to industry sources, contract volumes start at 700,000 tons per year in 2011, rising to 3.8 million tons per year in 2015. The remaining output from Peru LNG would be available for spot sales or additional term contracts (maps 1 and 2).²⁸

MAP 1 - Gas Infrastructure in Peru (existing and projected)



Source: Minister Pedro Sanchez, presentation made at Energy Week, World Bank, March 2009.

²⁸ Hunt Oil leads the Peru LNG consortium, which broke ground in January 2006, on a LNG export terminal at Pampa Melchorita, 105 miles south of Lima.

MAP 2 - Gas Infrastructure in Peru (existing)

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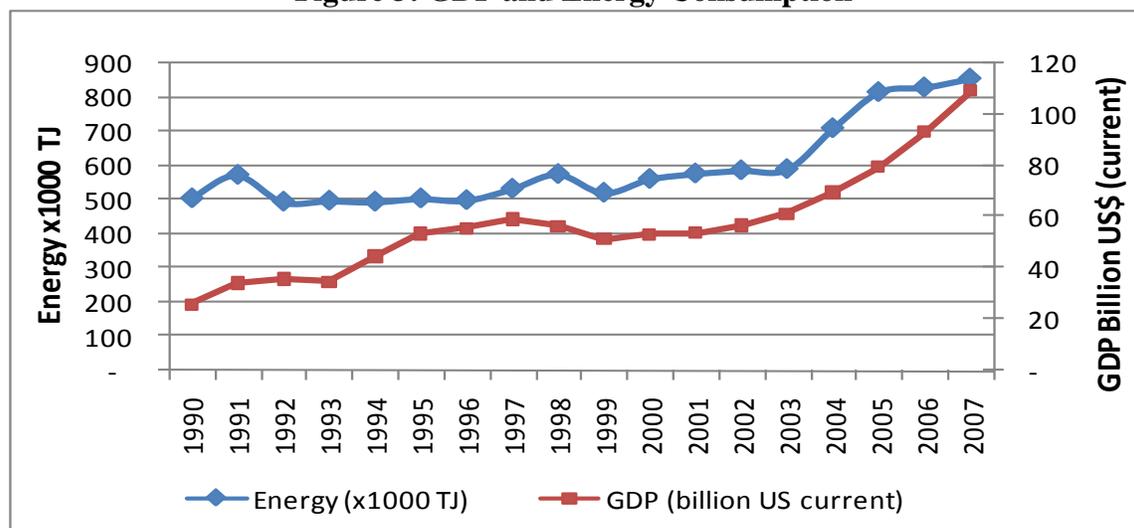


Energy Diversification in Peru

15. Four primary policy objectives have motivated the Government's actions in the energy sector.²⁹ The first is to increase the percentage of hydropower in the medium to long term, using available water resources and the processes of concessions that are underway. This would help to achieve the long-term target of approximately one-third of Peru's energy from hydro and other renewable sources, with another third from petroleum, and a final third from natural gas. A second policy objective is to increase the efficiency of thermal power generation by closing "open-cycle" plants and promoting the installation of combined-cycle plants. A third objective is to increase energy reliability and the security of supply through the expansion of domestic energy resources, especially natural gas. A fourth objective is to promote the development of "anchor demands" – large consumers such as power plants or large industrial facilities – that can provide the underlying demand for the development of production and distribution infrastructure.

16. In the power sector, new thermal generation capacity has been added in Peru as a result of the rapid response of private investors to meet electricity supply requirements in the 2004-2008 period. Figure 3 shows that the Peruvian economy has experienced a high economic growth rate since 2003, which in turn resulted in the increased demand for energy and electricity. The electricity demand growth in Peru since 2005 has been around 10 percent per year and is expected to continue growing at a rate of around 7.5 percent per year in the medium term. This growth in the demand for electricity will require approximately 400 to 500 MW per year of new generating capacity.

Figure 3: GDP and Energy Consumption



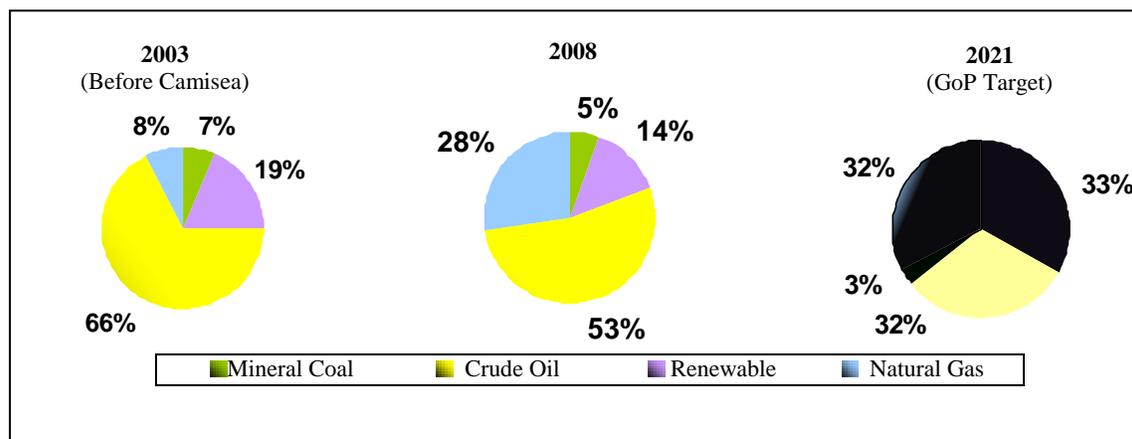
Source: WB estimation

²⁹ The policies for natural gas were stated in the document "Cambio de Matriz Energética y Desarrollo Sostenible: Objetivos de Política de Estado, Pedro Gamio Aita, Vice Ministro de Energía, 21 de Junio de 2007, Lima, Peru

Energy diversification by fuel source

17. Prior to the development of the Camisea Gas Field, Peru's energy matrix included predominantly petroleum products, followed by hydropower (figure 4). The government is committed to increasing the role of hydropower making use of domestic water resources, which is justified from both economic and environmental points of view. However, there has been minimal investment in hydropower for a number of years in Peru. The majority of the diversification of Peru's energy matrix in recent years has been due to the increase in natural gas consumption. The share of natural gas in Peru's energy matrix increased from 8 percent in 2003 to 28 percent in 2008. One of the factors that facilitated the increase in domestic demand for natural gas was the cost advantage of this fuel compared to other energy sources. In the Camisea scheme, the prices of natural gas for the domestic market were on favorable terms in order to encourage conversions from petroleum, especially in industry and power generation.

Figure 4: Evolution of the energy matrix in Peru



Source: Minister Pedro Sanchez Presentation at Energy Week 2009, World Bank, March 2009.

18. The initial phase of development of the Camisea Gas Fields was to supply gas to Lima and Callao. This region currently uses 94 percent of the gas produced by Camisea. Current gas consumption for the entire country totals 302 million cubic feet per day (MMCFD).³⁰ Gas from the Camisea gas field accounts for 83 percent of this total and the remainder comes from the zones of the Northwest, Talara and Tumbes, and from the Central Selva in Aguaytía.

19. Overall, the policies adopted by the GoP to promote the use of natural gas contributed to greater diversification of the energy supply. The production of liquid hydrocarbons from the Camisea gas fields – “natural gas liquids” – has been especially important for the profitability of the project in light of high international petroleum prices over the past five years. The profitability of natural gas liquids has been so important that natural gas production has been considered a byproduct of NGL production. This along with the high risk premium that was awarded to gas developers resulted in a series of

³⁰ 2008 estimate.

policies to keep the prices of natural gas low to promote gas use. Figure 5 shows the evolution of the primary energy supplies in Peru. The uses of natural gas began in 2004 primarily with electricity generation. As the share of natural gas has increased, the shares of petroleum products and biomass have dropped in the energy matrix.

Box 3. Overcoming Barriers to Hydropower

Hydropower has been the major source of electricity in Peru, traditionally supplying more than 80 percent of electricity requirements. Upon the development of natural gas in the early 1990s the Government of Peru's attention turned to providing incentives for the use of gas in power generation. With the rising demand for gas and increased attention to energy security and the impacts of climate change, the Government is paying renewed attention to hydropower. The recently-completed World Bank study on hydropower in Peru is aimed at assisting the Government in assessing the potential role of hydropower in the sector and the measures that could be taken to encourage its continued development.

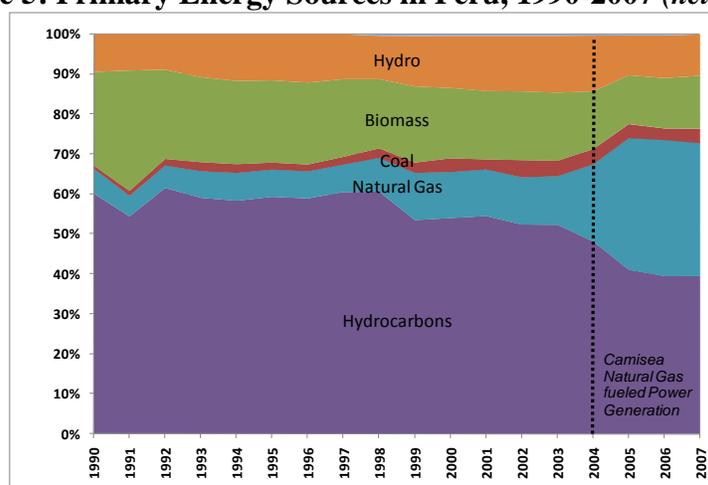
The study confirmed the potential role of hydropower in meeting the challenge of rising energy demand and contributing towards the development of a low-carbon economy. There are, however, barriers that are slowing this development. While hydropower is an economically viable option if natural gas is priced at its economic value, few hydro projects are financially competitive at the current low prices of gas for power generation in Peru (US\$2.14/mmBtu). Other barriers to the development of hydropower include the difficulties of financing a project when global financial markets have yet to recover, a regulatory system in transition, an auction system unfavorable to hydro projects, an uncertain licensing process, and a weak framework for environmental and social assessments.

Overcoming existing barriers will require a fresh look at sector policies, including revisiting the role of the State as policymaker, regulator and promoter, in order to ensure a reliable supply of power. The study recommends strengthening the following areas:

- A central planning effort that integrates strategic planning of power generation, power transmission, and natural gas in order to achieve a sustainable energy matrix.
- A pricing policy that better reflects economic values and fosters efficiency of consumption and investment.
- Holding electricity supply auctions by technology, including hydropower, as a way of overcoming the inherent difficulties of comparing technology costs in an objective manner. Also, prior environmental licensing should be a requirement for a project to participate in an auction.
- Revision of the open-ended nature of definitive concessions for hydropower projects as well as considering the award of these concessions at a more advanced level of preparation or, particularly for large projects, after a competitive process for the project has been held.
- Strengthening of environmental and social assessments for hydro projects, including open and legitimate consultation processes and the establishment of effective benefit-sharing mechanisms. A stronger environmental and social framework is of utmost importance for a sustainable development of the Amazon basin large-scale hydropower resources that is being considered under a bi-national agreement.
- Exploring the need for the Government to assist in mobilizing financing and/or, in selected cases, participating in public/private associations.

Source: The World Bank. 2009. "Peru: Overcoming Barriers to Hydropower."

Figure 5: Primary Energy Sources in Peru, 1990-2007 (net supply)



Source: MEM.

Prospects for diversification by sector

20. According to gas demand forecasts in the 2007 Hydrocarbon Reference Plan (PRH),³¹ production of gas from Camisea (See table 1) is expected to reach 1,962 MMCFD in 20 years, with an annual growth of 11 percent. Domestic demand would account for around 1,337 MMCFD,³² and LNG exports about 620 MMCFD. In this plan, the Lima–Callao region’s demand would account for 72 percent of the total, with thermal energy generation in open-cycle plants located in this region to be the primary consumer (centralized scenario).

Table 1: Forecast of Demand for Camisea Gas (MMCFD)

<u>Domestic Demand</u>	Current 2008	Share %	Year 5 2013	Year 10 2018	Year 15 2023	Year 20 2028	Share %	Variation (%)/yr
Res+Com+ Small Ind	1	0%	11	15	17	18	1%	17%
GNV	10	4%	20	31	37	39	3%	7%
Large Industries	77	31%	391	411	429	434	32%	9%
Thermal Generation	164	65%	235	440	683	847	63%	9%
TOTAL	252	100%	656	897	1166	1337	100%	9%

<u>Export Demand</u>	Current 2008	Share %	Year 5 2013	Year 10 2018	Year 15 2023	Year 20 2028	Share %	Variation (%)/yr
LNG	0	100%	625	625	625	625	100%	----
TOTAL DEMAND	252		1281	1522	1791	1962		11%

Source: Reference Plan – Hydro-Thermal Scenario

21. The transport infrastructure capacity will not be sufficient to meet projected levels of demand, so the current system capacity will need to be expanded, and new gas pipelines will be needed. According to the General Bureau of Hydrocarbons (DGH) and Calidda (the distribution company in the Lima area), TGP was to have a first expansion

³¹ See Hydrocarbon Reference Plan (2007-16) – DGH-MEM.

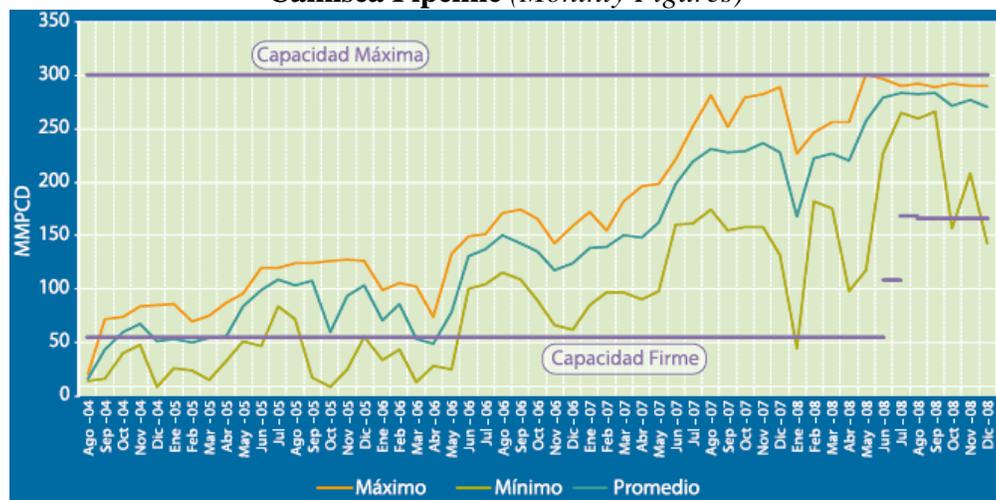
³² Forecasts of natural gas demand made by MEM (2007) include two scenarios for forecasts, which differ in terms of the projected thermal/hydro mix of electricity generation capacity. For analysis purposes, the hydro-thermal scenario is used.

of the main pipeline completed by August 2009, that will lead to a transport capacity up to 380 MMCFD. A second expansion by the end of 2009 was to increase capacity up to 450 MMCFD, while the DGH has demanded TGP to increase up to 1,000 MMCFD by 2012. Apparently, TGP is considering this plan and a discussion with Peru LNG is underway to share use of this pipeline.

22. The transport capacity of the system operated by the Gas Transportation Company of Peru (TGP) is around 315 million cubic feet per day (MMCFD), which is enough to carry out the 160 MMCFD of firm capacity contracts—around 55 MMCFD up to May 2008. However, during the third trimester of 2008, calls for transport capacity reached 400 MMCFD, far above the maximum capacity, and some restrictions were implemented. Currently, the daily production capacity of Camisea is above 400 MMCFD, however, recent demands for firm transport capacity (during the last round of competitive bidding for transport capacity named Open Season call) reached 600 MMCFD. This increase in transport demand has been driven by Decree 1041 (2008) requesting natural gas thermal generators to have firm transport capacity in order to receive capacity payments.³³

23. An expansion of the existing transport capacity and the construction of new pipelines are underway. Figure 6 shows the evolution of the volume of natural gas transported. Savings from a combined-cycle technology would help to reduce the pressure for new capacity expansion on the TGP pipeline.

Figure 6: High, Low, and Average Volume of Natural Gas Transported in the Camisea Pipeline (Monthly Figures)



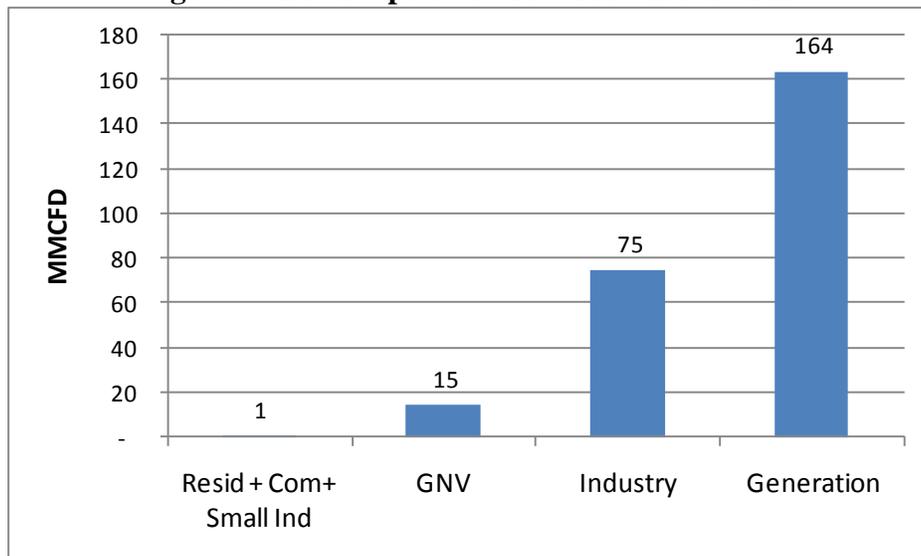
Source: Boletín Informativo de Gas Natural (segundo semestre 2008), OSINERMIN.

³³As long as demands for natural gas firm transport are above the maximum level, the requirement of attaching firm (transport) capacity to power capacity payments will not be necessary. Simply, thermal generators will be induced to secure transport capacity to be dispatched—otherwise, they will be rationed and required to run on more expensive liquid fuels if they wish to be dispatched. If they contract no firm but interruptible capacity, this will affect the dispatch of thermal generators. Inefficient generators, whose likelihood of being dispatched is low, may be tempted to not contract firm transport capacity.

24. The sector that consumes the most gas from Camisea is electricity generation. Figure 7 shows that the demand for electricity generation accounts for 65 percent of total consumption. The remaining demand is spread among industrial and small-scale consumers (households, businesses, and natural gas for vehicles).³⁴

25. Power generators and industrial users have benefited the most from the supply of natural gas, which has allowed them to diversify their sources of energy. Contributing factors to their increasing use of gas were their proximity to the transport and distribution network and the security of having low regulated prices for the resource. It is likely that power generators also benefited from the mechanism used to finance the transport infrastructure through the GRP (Garantía de Red Principal) instrument and from the excess capacity in transport and gas availability which eliminated the need for having a costly firm capacity contract.

Figure 7: Consumption of Camisea Natural Gas

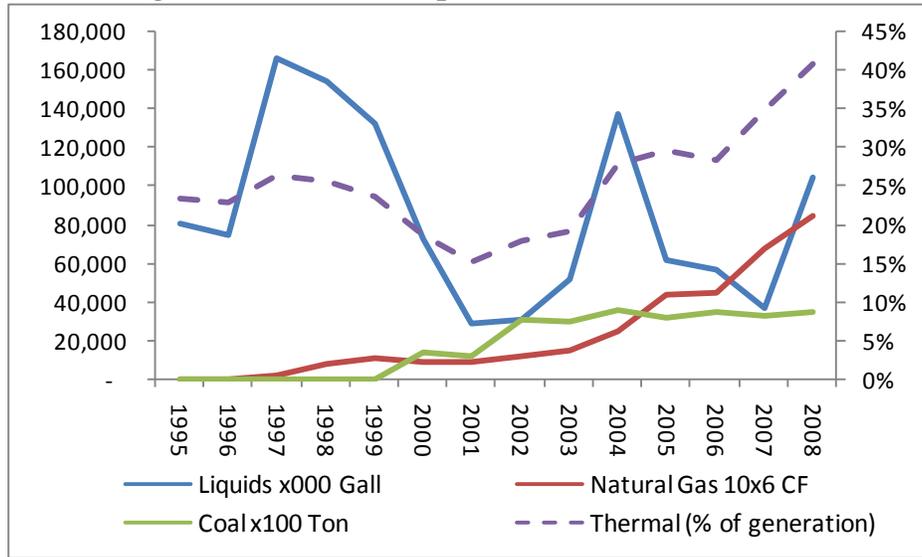


Source: MEM

26. Despite the rapid shift to gas-fired technology in the power sector, liquid fuels still play a key role in supporting the growth of electricity consumption. Figure 8 shows that liquid petroleum fuels (diesel, residual, and fuel oil) have served as a back-up generation to natural gas when additional thermal production was needed.

³⁴ The volumes shown in the table correspond to available data for January–March 2008; for the case of power generation, the *Estudio de Capacidades Contratadas* was used. This study was submitted to OSINERGMIN by the Gas Transportation Company of Peru (TGP) in November 2007, under the framework of the process of revising the transport tariff of the principal network.

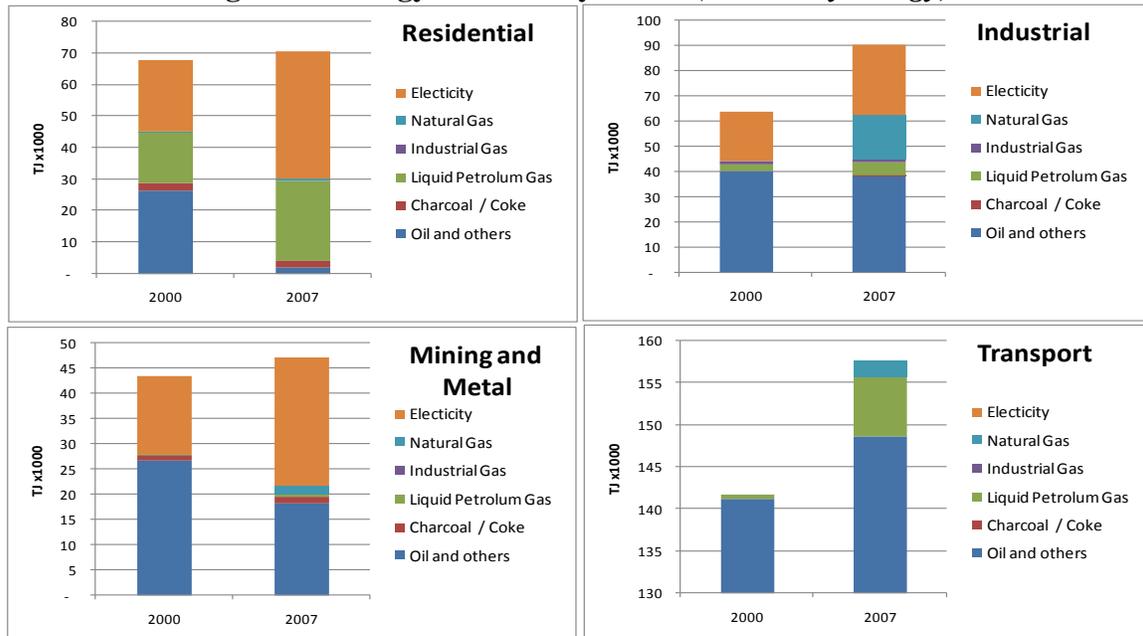
Figure 8: Fuel Consumption for Power Generation



Source: COES 2008.

27. Other sectors have had a more modest increase in the consumption of natural gas (figure 9). In the transport sector, the number of natural gas vehicles (NGV) increased during 2008 but natural gas still remains a secondary fuel for transport, in part because it is only delivered in the Lima area, and there are only 32 stations. According to MEM, the number of refueling stations will be expanded to 185 and gas supply for transport will be expanded to other cities over the next five years.

Figure 9: Energy Demand by Sector (Secondary energy)



Source: MEM

28. Residential consumers benefited from the production of Camisea in two ways: directly, by substituting kerosene by liquefied petroleum gas (LPG); and indirectly, through their electricity consumption that was increasingly generated by relatively low-cost natural gas. The development of the piped natural gas network has been restricted to certain neighborhoods in Lima and has been negatively affected by high connection costs and subsidized LPG. The private sector has also had limited interest in investing in the residential sector given the relatively small size of the market. Most residential natural gas is used for cooking, since Lima's temperate climate precludes the need for extensive space heating of homes.

29. In sum, Peru has succeeded in diversifying its sources of energy through the development of natural gas, which today plays an important role in the country. Large and energy-intensive sectors have benefited the most from the natural gas produced from the Camisea gas fields. Power producers and large industrial users have adapted their technological processes due to favorable pricing and secure supplies. Other final consumers have not increased their consumption of natural gas substantially, but electricity consumers have benefited indirectly from lower electricity prices compared to the case if electricity had been generated from petroleum. Residential consumers have replaced most kerosene consumption by LPG, which is highly subsidized, instead of with natural gas or electricity. Connection costs, coupled with low residential energy demand, have been the main constraints for increasing natural gas consumption. For vehicular transport, vehicle conversion costs, refueling infrastructure, and the lack of an extensive regional gas network has limited the expansion of natural gas. The new Metropolitan bus system will increase the consumption of natural gas, which will have positive air quality and health benefits, compared to conventional diesel fuel.

III. Potential New Markets for Natural Gas

30. One of the main tasks of the study was to evaluate potential new markets for natural gas in Peru. In addition to the four current sectors that are consuming gas in Peru – (1) electricity, (2) industry, (3) residential and commercial, and (4) transportation – there is also potential for establishing a petrochemical industry based on gas. Given the dominant nature of the power sector thus far, and the extensive analysis that has been done for the power sector, the analysis focused on the four other sectors for review.

31. For the purpose of estimating the value of natural gas in Peru for different end-uses, the study adopted the use of “netback prices.” Netback pricing is a method for calculating the international value of a commodity that may not be directly traded, and to be able to determine the value of the gas at different points in the supply chain, for instance at the wellhead or at the factory gate. Netback pricing is a common method of linking domestic gas prices to international prices, either of natural gas (such as Henry Hub gas prices in the U.S. Gulf Coast) or of close energy substitutes (such as petroleum products), and has been used by major gas producers and consumers such as Mexico and Russia to rationalize domestic gas pricing.

Industry

32. The demand for gas by the industrial sector shows a high potential consumption in a handful of large companies. Moreover, due to the current configuration of the supply network, consumption is concentrated in the region of Lima and Callao. This concentration of demand among only a few customers is even more evident in other regions of the country.

33. There is a wide gap between the cost of other fuels and that of natural gas. Given the overall higher prices for petroleum on the international market, the possibility of having access to lower-cost natural gas has facilitated the sustained growth of industrial demands for gas. The study estimates that the netback value of natural gas for industry varies from US\$7/MMBtu to US\$10/MMBtu.³⁵ These values are much higher than the current promotional value for industry in Peru of US\$2.4/MMBtu, showing the enormous price advantages of using natural gas in the industrial sector.

34. The extent to which industries can quickly convert to natural gas helps to encourage the construction of regional gas pipelines. Large-scale industry, not including the petrochemical sector, will be a significant driver of the domestic demand for gas in Peru, which is estimated by the Government to reach an estimated 290 MMCFD in 20 years; this figure amounts to about 22 percent of the country’s total consumption by that time.

³⁵ Netback prices represent the maximum willingness-to-pay for natural gas by different end-users, such as industry and the residential sectors. The netback pricing methodology used for this study determines the energy value of the natural gas (US\$/MMBtu) as equivalent to the international value of the relevant substitute fuels that the gas is replacing (see Methodological Note for the detailed methodology).

Transport

35. A unique feature of the market for natural gas for vehicles (NGV) is that the demand typically develops first in large urban centers and then extends to other regions with the extension of gas transport infrastructure. If the demand for gas continues to be concentrated in the Lima–Callao region (the “centralized scenario”), it is likely that the demand for NGV would also be concentrated in this area. However, since the Lima–Callao region accounts for nearly two-thirds of the country’s automobiles, even limiting the use of NGV to this region could theoretically supply a significant portion of the country’s vehicle fleet. Another important factor in the development of the NGV market is the large cost to consumers that is needed for converting vehicles from liquid fuels to gas, or of maintaining flexibility by making them bi-fuel.³⁶

36. Since the arrival of gas in Lima-Callao, there has been a rapid growth in demand for natural gas for transportation, with about 35,000 vehicles³⁷ in mid-2008 using NGV, or about 5 percent of the automobile fleet in Lima-Callao. According to MEM, by 2033 consumption of natural gas for transport is estimated to be 38.5 MMCFD, compared to about 15 MMCFD in 2008. The number of gas refueling stations would increase from 32 in mid-2008 to 185. The experience drawn from studies conducted for the regions of Ayacucho, Arequipa, Ica, and Junín shows that the potential growth of NGV would be modest compared to Lima-Callao.

37. There are several factors indicating that the official forecasts are achievable:³⁸ (a) the financial benefits of switching from liquids to gas are positive, due to the pricing of natural gas compared to substitute fuels; (b) the mechanisms to finance conversions are becoming effective; and (c) the profitability of natural gas service stations in the initial stage of development is high, which encourages people to open them, but this in turn causes profits to erode over time.

38. Price advantages for natural gas for vehicles are often justified in the initial stages of development in order to overcome the resistance of potential consumers to convert their vehicles, and to provide the necessary encouragement for expanding the supply of NGV. But these incentives, especially those incorporated in NGV pricing, should decrease over time as the market develops and as other disadvantages – such as limited availability – disappear. There are also typically significant air quality and health benefits that can be gained by converting vehicles (and especially conventional diesel buses) to natural gas. Ultimately, the extent of usage of NGV will be limited by the expansion of the natural gas pipeline system which in turn will depend on the level of reserves.

³⁶ For retrofits, the most costly elements are the tank and conversion kit. For new dedicated natural gas vehicles, the initial capital cost is the relevant factor.

³⁷ In mid-2008, the natural gas industry predicted that the number of natural gas vehicles in Peru would total 60,000 by the end of 2008.

³⁸ Currently, the investment made in converting the vehicle from gasoline to NGV is recovered in less than one year for a private vehicle, while the time is reduced to three to four months for a taxi that is driven an average of 200 km per day (OSINERGMIN 2008).

Residential and commercial

39. Although socially significant, the current and future market for residential and commercial consumers is small relative to total gas demand in Peru. Forecasts reflect this in all regions.³⁹ The experience of gas distribution in Lima and Callao shows that one of the barriers to higher penetration is the low consumption of substitute fuels (cooking based mainly on LPG). When deciding to connect, the user must evaluate the fact that a fairly large investment in connection and internal installation costs is being made for a relatively small amount of gas consumption. The incentive to connect is reduced if it is not possible to finance these costs over time.

40. Progress has been made on overcoming the barrier of the installation cost. Under the new tariff regulation adopted in 2007, the cost of the service connection and pipes is financed by the lender through the payment of a fixed charge of US\$2.5/month, which is charged to the user's bill. In addition, the lending company has promoted a policy to finance the user's inside installation, which consists of extending the financing period from five years to eight years, with the payment of a US\$3.2/month fee. As a result of these new policies, the gas distribution company in Lima-Callao estimates that in a period of five years (2008–12), the number of residential users will increase from 12,000 at present⁴⁰ (with 70,000 potential users of the network) to 100,000 connected users (with 200,000 potential users of the network). In 25 years, 325,000 residential customers may be reached in the region of Lima-Callao, with an estimated consumption of 7.2 MMCFD (0.5 percent of the country's internal demand).

41. Increased access to natural gas by residential users also depends on the substitute fuel pricing policy. It has been shown that a policy to improve access to the network cannot be based on consumption subsidy policies which only benefit those who already have access. In this regard, it would be worthwhile to set up a program to subsidize fuel consumption for low-income consumers (using the databases of existing social assistance programs) but not a general subsidy of LPG, which also provides subsidies to medium and high income consumers. In the residential sector, a factor that decreases the incentive for connection to piped natural gas is that the price of LPG (the main competitor of natural gas) has a high subsidy component (30 percent). Because gas network coverage is limited, the government may consider alternative solutions that do not rely on LPG subsidies. Cash transfers programs for those regions in which networked natural gas supply is not available can be constructed in a way that minimizes the risk of exclusion of those who cannot afford the full price of LPG, while limiting the risk of inclusion of high income consumers. There are numerous examples such as the Chile stabilization fund, that show how the use of social databases and cash transfer programs for infrastructure service delivery are constructed and implemented.

³⁹ Despite the substitution of types of energy used by these segments for cooking and heating, they show a high economic benefit, releasing more costly resources (liquefied petroleum gas [LPG], kerosene, electricity).

⁴⁰ Estimate as of end-2008.

Petrochemicals

42. Peru currently lacks a petrochemical industry, and relies on imports of chemical and petrochemical products.⁴¹ As mentioned, the potential of natural gas resources in the country has raised the possibility of developing a petrochemical industry in Peru. In this context, the GoP's role in facilitating this development will be vital in the following aspects: (1) definition of the location of petrochemical hubs; (2) conditions for the use of infrastructure that supports the hub: port, gas pipelines, water, electricity, housing, roads;⁴² (3) definition of objectives and priorities; and (4) regulations/incentives that define technical features of the plants,⁴³ and priority of gas use and price conditions for the petrochemical industry.

43. At the GoP's initiative, in October 2007 Pluspetrol launched a bidding process for the development of a methane-based petrochemical hub whose size represents a commitment of 1.5 Tcf to 2.0 Tcf of reserves in 30 years. The winning bid was around US\$3.1/MMBtu for US\$300/ton of urea, with a maximum of US\$7.0/MMBtu for a urea price of US\$620/ton.⁴⁴ A recent Background Paper produced by the World Bank on the petrochemical sector estimated a netback price for urea production varying from US\$3.0/MMBtu to US\$7.0/MMBtu for urea values between US\$400/ton and US\$500/ton. These contracts to supply gas did not take into account the cost of the additional infrastructure that the dry gas hub would require. Based on the recommendations of a study the GoP is still undertaking, an international company would be awarded the contract to construct this infrastructure. This company would recover its investment through a fee to be charged for these services. It is not clear that the impact of the costs of this infrastructure has been taken into account in natural gas price negotiations.

44. The port infrastructure, which for dry gas would be located in Marcona, would be the GoP's responsibility. For this purpose, the National Ports Company of Peru (ENAPU) has commissioned a ports study.

45. For ethane, no bidding is currently underway,⁴⁵ and there is a significant lack of definition regarding the location of the olefin-polyolefin hub and thus the possible costs of ethane. A preliminary analysis conducted as part of this study indicates that for polyethylene prices typical of recession periods (The People's Republic of China stops buying and the Republic of Korea exports to Latin America), the netback price of the ethane at the Malvinas plant would end up being negative. However, for polyethylene prices above US\$1,000/ton, ethane has a positive and relatively high value.

⁴¹ In 2006, nearly 1.5 million (MM) tons of products were imported valued at nearly US\$1,000 MM.

⁴² It is acknowledged that there is a major deficit of infrastructure in any of these locations.

⁴³ For example, whether "not new" plants may be developed

⁴⁴ The average international price of urea in 2009 (Eastern Europe, bulk) was 250 US\$/metric ton, down from 493 \$/mt in 2008. Commodity Markets Review, January 13, 2010, DECPG, World Bank.

⁴⁵ A study is being conducted on ethane recovery and logistics, which would include possible locations for an olefin hub that, according to sources consulted, would be completed in a few months.

46. A number of logistical difficulties need to be overcome by the Government for the development of an ethane industry. The ethane that could be separated at Pluspetrol's Malvinas plant with several modifications to the process has serious logistical difficulties in terms of the transport of the ethane to the consumption point. The current 14-inch multipurpose pipeline, which conveys liquids to Pisco, is not suitable for ethane. Several options are being studied, all of which have high costs and environmental issues. The resolution of the logistical issues, which in turn is associated with the design of new gas pipelines, is contingent upon the possible location of the olefin complex.

47. The development of a petrochemical industry requires a high level of natural gas reserves. If reserve levels are at the high end of nearly 50 Tcf, this would justify a long-term plan for petrochemical development. Petrochemical development would also mean that competition for products would no longer be at the national or even regional level, since the petrochemical industry would compete with other international natural gas producers and their petrochemical products. It would be important to analyze the plastic raw materials sector in order to define strategies that allow for petrochemical development to make use of polymers at competitive prices. Currently, and pending definitions by the GoP, the forecast for gas consumption by the petrochemical sector could be based in principle on the volumes involved in the above-mentioned bidding for methane gas. This includes the bidding of 150 MMCFD for the production of urea and ammonium nitrate.⁴⁶ Additional details could be found in a World Bank background paper entitled *Opportunities and Challenges for the Development of a Petrochemical Industry in Peru*.

⁴⁶ Fifty MMCFD for methanol are not included, since the bidding showed no progress to date for this product.

IV. Issues and Options for Improving Peru's Downstream Gas Sector

48. This chapter discusses some of the key issues and concerns related to the development of Peru's downstream natural gas industry. The review looks at the effectiveness of the sectoral policies vis-à-vis the objectives pursued by the GoP. In addition to the issues of energy diversification and generation capacity mix that have already been discussed, this chapter analyzes five additional issues: (1) the role of natural gas reserves; (2) energy efficiency potential in the use of natural gas, particularly by the power sector; (3) integrated energy planning; (4) the expansion of natural gas transport infrastructure; and (5) natural gas pricing.

Natural gas reserves

49. There is a need for more precise and reliable data on the potential size of proven, probable and possible natural gas reserves in Peru. The gas reserves base in Peru has been the object of considerable speculation over the past several years. There has been a lack of available data on the potential size of probable and possible reserves, and the estimates have been from multiple sources and not sufficiently reliable. According to MEM's Dirección de Hidrocarburos (DCH), Peru possesses between 8.8 and 11.0 Tcf of proven reserves. Geologists, operating companies and Perupetro estimate a potential close to 50 Tcf. Many exploration contracts are under way and according to different sources in the country there is a high probability of adding new reserves in the coming years. However, there is an urgent need to increase the reliability and quality of reserve estimates so as to facilitate a clear strategy for natural gas development.

50. Depending on the level of reserves, different types of natural gas consumer industries and businesses could be promoted. To maximize the value of natural gas, gas reserves could be assessed at their opportunity cost of selling to the international markets or based on a netback methodology for domestic customers, whichever is higher. A medium time horizon to guarantee the domestic supply (10 to 12 years) would be potentially more effective to promote new explorations and increase the probability of new finds, compared to the 20-year horizon that is used today.

51. Recently, due to natural gas supply limitations, MEM has established a priority list for the supply of natural gas. The Government has indicated that a first priority is to maintain existing contractual obligations, mainly the LNG export contract with Mexico. For the domestic market, the order of priority starts with gas supply to residential consumers, followed by natural gas for transportation, and then natural gas for power generation (for combined cycle first and, then, for open-cycle units). Industrial and commercial users have been relegated to the bottom of the list and will need to compete

with future exports for natural gas supply. Future gas supply priorities will depend on the level of gas reserves and gas production.⁴⁷

52. Under a high reserve scenario, both the expansion of gas for domestic users and export markets become attractive options, which could allow Peru to sell natural gas and value-added products to regional and global markets. If large reserves are available, big domestic consumers of natural gas such as power plants, petrochemicals, the ethane industry and even fertilizers are feasible options, beyond residential, commercial, transport, and small- to medium-size industries. To date, the only sizable private sector investment in the gas sector in Peru has been the Camisea LNG export project.

53. Under a lower reserve scenario, the government may wish to prioritize development for the domestic market (including power, households, transport, and small industries). Some of the investments under way in the natural sector are the Lima natural gas distribution network and the construction of a pipeline to the southern part of the country. There are many other options to develop the domestic natural gas sector, but the scale of that development should be in line with proven gas reserves. If only limited reserves are available, the country and decision-makers should define their priorities on the type of uses for the existing gas reserves that they want to encourage for the domestic natural gas market.

Energy efficiency potential

54. In Peru, the mix of thermal and hydro for power generation has been relatively stable over the past 10 years. Nevertheless, considerably more thermal generation capacity (mainly open-cycle natural gas technology) was installed between 2004 and 2008. Figure 10 illustrates the trend of installed power capacity vis-à-vis the unregulated price of electricity.⁴⁸ As can be observed, there is a high correlation between incremental additions to thermal capacity and the electricity price; the correlation is even higher with a two-year lag in prices, demonstrating the delay in price signals on power investments. Given its lower upfront costs, open-cycle technology was rapidly deployed and the expansion was facilitated by the abundant supply of natural gas through an uncongested pipeline.

55. The GoP estimates that closing open-cycles plants could contribute between 800 and 900 MW, with the same amount of natural gas. This is equivalent to about two years of new power plant capacity in Peru. In addition, if all natural gas power plants in Peru in 2008 would have used combined-cycle rather than open-cycle technology, savings in natural gas would have amounted to 28 percent of total gas consumed by the power sector.

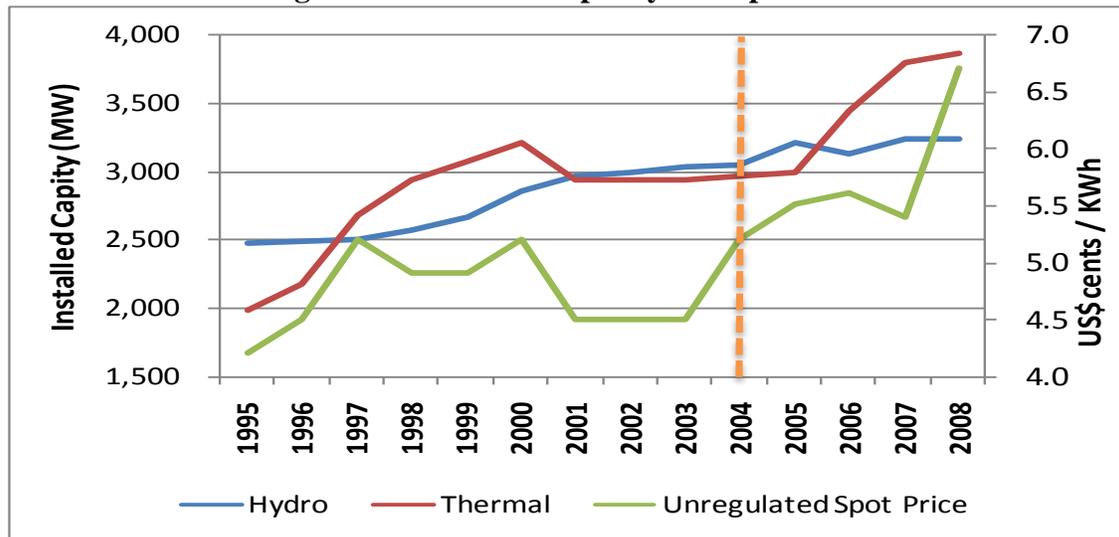
56. Table 2 shows natural gas consumption in power generation in the period 2007-2008. All power plants in the table are open-cycle except TG Ventanilla Gas, which is a

⁴⁷ A Methodological Note on *Natural Gas Valuation* describes in detail the valuation procedure for different types of users of natural gas.

⁴⁸ Unregulated monthly average spot price reported by COES.

combined-cycle plant. The efficiency of an open-cycle plant is on average 40 percent lower than the combined-cycle technology. The savings in natural gas that could be achieved through combined-cycle technology should be compared with the investment costs of closing open-cycle plants. The export price of the natural gas by Peru LNG can be used as an upper bound of the value of the natural gas.⁴⁹

Figure 10: Installed Capacity and Spot Price



Source: Authors estimates based on statistics published by the COES –SINAC

Table 2: Natural Gas Consumption and Fuel Efficiency in Power Generation

Power Unit	2007			2008		
	Electricity GWh	Natural Gas MCF	Efficiency Rate KWh/MCF	Electricity GWh	Natural Gas MCF	Efficiency Rate KWh/MCF
Malacas TG1	23.8	364,312	65.3	29.5	470,678	62.6
Malacas TG2	37.2	587,839	63.3	49.7	765,754	64.9
TG2 Aguaytía	560.9	7,043,247	79.6	587.1	7,244,926	81.0
TG Santa Rosa UTI -Gas	125.0	1,541,176	81.1	256.5	3,133,356	81.9
TG1 Aguaytía	580.7	6,988,746	83.1	636.6	7,648,949	83.2
Malacas TGN4	533.9	5,987,685	89.2	606.0	6,766,561	89.6
TG Santa Rosa WTG -Gas	296.1	3,313,512	89.3	171.2	1,826,562	93.7
Kallpa	279.9	2,749,180	101.8	987.6	9,746,546	101.3
Chilca TG2	632.9	5,778,758	109.5	1,272.0	12,094,508	105.2
Chilca TG1	1,323.6	12,401,683	106.7	1,288.9	12,022,305	107.2
TG Ventanilla Gas	2,916.1	20,075,619	145.3	3,433.6	22,494,283	152.6
Overall	7,309.9	66,831,756	109.4	9,318.7	84,214,428	110.7

Source: COES (2008).

57. One of the ways of improving the efficiency of natural gas consumption is the establishment of a realistic policy for natural gas prices within the framework of an overall energy plan (see following section on natural gas pricing). Low gas prices penalize investments in efficient natural gas technologies.⁵⁰ The calculations show that to

⁴⁹ Assuming that domestic consumers are willing to pay less than the export price

⁵⁰ The reason is simple when open and combined cycles of thermal plants are compared. In the case of combined cycle thermal plants, greater investments are required in order to save fuel and produce an equal

stimulate the construction of combined-cycle natural gas plants requires that gas prices be at least between US\$0.5/MMBtu and US\$1.0/MMBtu above the current value measured at the power generation plant.⁵¹

58. In addition to efficiency impacts, gas prices also have an effect on the development of hydropower. Preliminary calculations indicate that, with a natural gas price of US\$2.2/MMBtu at the delivery point, electricity generation using natural gas would be more economical than hydroelectricity, provided that the investment costs for hydro are close to US\$1,500/kW. Since hydro costs are likely to be above this figure (World Bank 2009, see box 3), there are currently major disincentives for the construction of hydroelectric plants compared to natural gas plants.

Integrated energy planning

59. The GoP needs to play a key role in supporting the development of the energy sector. Government involvement is needed on a range of issues from the provision of credible and objective information to regulations that promote the use of the most efficient technologies. The domestic demand of natural gas needs to be calculated in an integrated manner, taking into account the demand of the electricity sector as the main consumer, as well as other users including industry, petrochemicals, residential and commercial, and transport vehicles. To increase private sector investment in exploration and development in the natural gas sector, the Government could actively develop planning tools, and its role strengthened in the following areas: (i) natural gas sector planning and availability of basic information (for instance, geological and reserve data); (ii) pricing policy and adequate regulation to guide private sector development; and (iii) development and implementation of clear rules for the award of competitive project concessions.

60. One of the key roles of the government is to review the priorities for natural gas development in different locations and for different end users. A complete spatial and geographical integrated energy planning exercise is needed to support the expansion of the natural gas network (see following section). To address the requests of potential natural gas consuming industries, the planning exercise should be conducted jointly with the private sector. A case in point is the petrochemical industry, where the debate is over where the industry will be located and what will be the cost of the related infrastructure and who will provide it. As suggested by the GoP, the Consortium that administers Camisea signed a pre-agreement to secure natural gas for the petrochemical sector that also specifies a price. However, such an agreement could also consider where the industry is going to be located, since this will affect the cost of infrastructure and the

amount of energy. The change in cycle will be carried out provided that the savings in terms of fuel expenses exceed the increased cost for additional investments.

⁵¹ It is estimated that the price of any natural gas at the plant, which equals the generating costs of an open cycle versus a combined cycle, is US\$3.1/MMBtu. Considering a transportation cost via a gas pipeline of US\$0.85/MMBtu (equivalent to the actual value of the TGP), a netback of US\$2.25/MMBtu is obtained at the wellhead, a price US\$0.75/MMBtu higher than the promotional price for gas from Camisea with this destination (US\$1.5/MMBtu).

netback value of the gas. Moreover, the willingness to pay for the natural gas is likely to change depending on how the cost of infrastructure development is shared.

61. It is important for the GoP to address regional gas plans within an integrated hydrocarbon and electricity plan that incorporates the objectives of regionalizing gas use, with the aim of achieving the lowest energy cost. In an integrated energy plan, an adequate assessment of the economic or “opportunity” cost of gas for electricity generation should be taken into account. The integrated assessment of electricity and hydrocarbons would help the Government prioritize actions in at least two aspects: (a) which projects—regional gas pipelines, transmission lines, and gas-operated thermal power plants—require active support to be implemented, and with which instruments, and (b) what other types of incentives/regulations should be introduced in order to achieve the plan’s results.

62. The regional promotion of natural gas will necessarily create some efficiency-equity tradeoffs in which the authorities will need to assess the benefits and costs of each option. For instance, when opting for transmitting electricity or providing natural gas supply to areas with high costs or in less-developed regions, mechanisms to reduce the costs for final consumers need to be evaluated. Moreover, the overall set of policies may not be consistent with, or may even be in conflict with, broader national objectives, such as when promoting hydropower generation or natural gas-fired power plants. The bottom line is that energy policies need to be evaluated within an integrated planning framework that includes natural gas and other sources of energy, including their related infrastructure costs. This includes a detailed assessment of the efficiency-equity tradeoffs of different options.

63. The private sector has played a major role in the development of infrastructure and the hydrocarbon sector in Peru, with the public sector enacting regulations to guide private sector investment. Given the sector’s dynamics, a long-term outlook is required, with ongoing planning work by the GoP and continual sharing of information and forecasts between public and private actors. To attract private investors and to avoid costly delays, it is important to define a regulatory framework consistent with the objectives of the medium and long-term planning. Among the decisions to be made by the Government is the definition of the type of private capital participation, the compatibility of the private investments with energy policy objectives such as those dealing with the location of thermal energy plants and tariff policy, and meeting specific targets for penetration and use of natural gas in Peru. Other questions relate to whether the Government should specify issues such as the type of technology (e.g., combined-cycle plants) or the location of new power plants, or can the government use other mechanisms (such as auctions) to determine those characteristics?⁵²

⁵² Brazil is a good example in which the regulator plays the role of the auctioneer of hydroelectric capacity to the private sector; this requires that distributors secure 100 percent of their load with PPAs. For example, power projects already having environmental assessment could be auctioned by the GoP to limit the exposure of private investors.

64. One area where public sector analysis is needed is the supply of natural gas to relatively small-size consumers. It is important to consolidate small demands together with anchor demands, clearly indicating the priority in natural gas supply. Small demands should be integrated into the network relative to large gas users such as power generation, petrochemicals, and large industrial consumers in such a way as to facilitate the construction of the infrastructure but not with cross-subsidies so large that none of the projects are profitable. In this regard, an issue to be defined is whether the joint or separate development of small and large consumers is appropriate. Zoning and geographical studies could be undertaken to evaluate the advantage of being served by the natural gas network via pipelines compared to the costs of receiving gas such as LPG in canisters or CNG by trucks.

65. Institutional and human capacity building in the natural gas sector is important to provide the Peruvian gas sector with the ability to develop both the domestic and international markets. The youthfulness of the natural gas industry in Peru, coupled with its highly technical and complex characteristics, underscores the importance of having adequate technical capacity to provide strategic planning for the natural gas sector within the overall energy sector.

Expanding natural gas transport infrastructure

66. The expansion of the gas transport infrastructure will be required in order to meet any of the supply plans for natural gas. In this regard, the level and spatial location of projected demand throughout the country will determine infrastructure requirements. The demand scenarios analyzed here — centralized and decentralized — are based on Government plans and will require very different designs for the transport subsystems. The associated costs of each alternative and the mechanisms for their recovery — such as through different transport pricing and/or subsidy alternatives — are a key issue for the Government to achieve large-scale expansion and regionalization of the gas market.

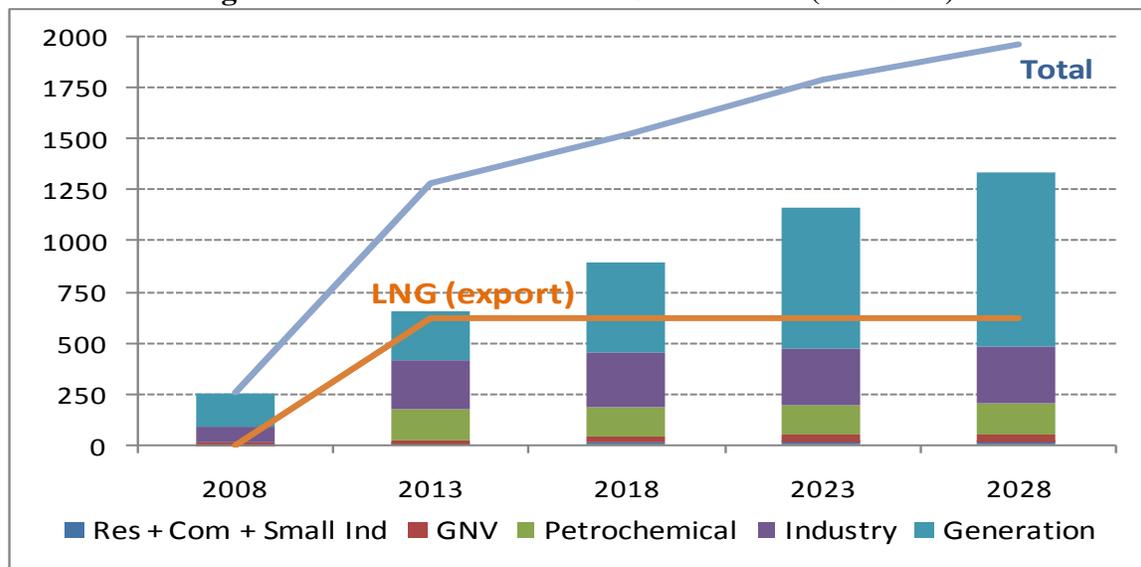
67. Under a centralized gas plan, the bulk of electricity generation would be concentrated in the Lima area, which, in turn, implies large investments in the transmission of electricity to supply other regions of the country from this electricity hub. There has been some criticism about the current concentration of electricity generation in Lima — essentially the centralized scenario — with Regions fearing that the reliability and security of electricity supply from Lima may be jeopardized if there is an interruption in the flow of gas from Camisea. An alternative scenario is to transport gas to regional power plants as opposed to the transmission of electricity, which would require a different set of investments in infrastructure.

68. The Ministry of Energy and Mines (MEM) has projected different scenarios for the demand of natural gas for the next 20 years. According to forecasts in the 2007 Hydrocarbon Reference Plan (PRH),⁵³ production of gas from Camisea would reach

⁵³ See Hydrocarbon Reference Plan (2007–16), General Bureau of Electricity–Ministry of Energy and Mines (DGH-MEM).

approximately 1,962 MMCFD in 20 years, with a growth rate of 11 percent per year (See Figure 11). This demand would be distributed as follows: 1,337 MMCFD for the domestic market and 625 MMCFD for liquefied natural gas (LNG) exports. In this plan, the Lima-Callao region’s demand would account for 72 percent of the total. Since this scenario assumes that the main consumer sector, electricity generation in open-cycle plants, would be concentrated near Lima-Callao,⁵⁴ this is called the “Centralized Scenario.”

Figure 11: Forecast of Camisea Gas Demand (MMCFD)



Source: MEM Reference Plan – Hydro-Thermal Scenario.

69. As an alternative to the centralized scenario, the authorities are evaluating another scenario that *decentralizes* the increase in generation from Lima to the country’s Northern and Southern zones. The Lima region would no longer constitute a hub for electricity exports to these regions; each region would supply itself, thus making the system even more reliable. This *Decentralized Scenario* assumes the development of two new gas pipelines: (a) Lima-Chimbote, and (b) Camisea-Ilo. This alternative would promote gas regionalization, since it would facilitate the development of regional gas pipelines through savings from anchor demands for incremental electricity generation. In addition, this alternative could incorporate consumption by a petrochemical industry and other potential demands in Arequipa, Ilo, Moquegua, and Tacna. In this regard, the following petrochemical demand is envisioned: (a) urea: 100 MMCFD, and (b) ethane and ethylene/polyethylene production: 90 MMCFD.⁵⁵

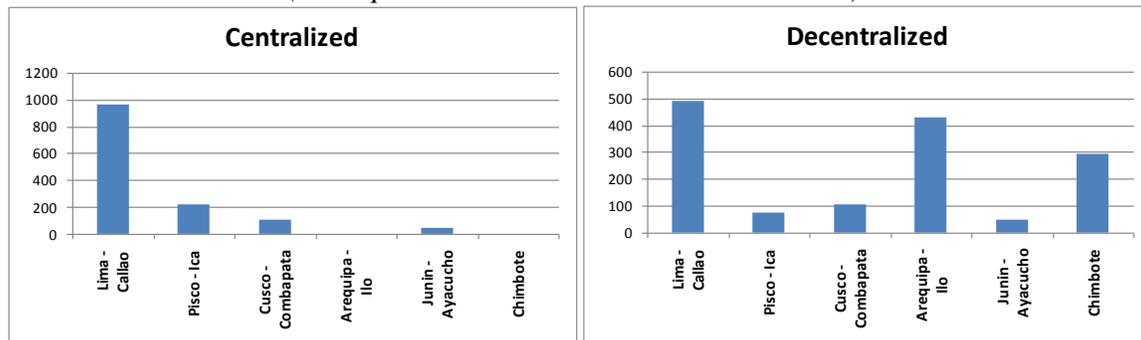
70. Figure 12 shows the key differences between the centralized and decentralized scenarios, identifying variations by service zones. It logically notes the lower

⁵⁴ Gas-powered thermal capacity in this zone would increase by 1,690 megawatts (MW), from 1,190 MW (2007) to 2,880 MW (2015).

⁵⁵ Although the installation of a urea plant in Ilo may be feasible, recent discussions tend to indicate Marcona as a port and a plant site. For ethane, the supply route, separation points, and plant locations are still under discussion.

consumption concentrated in Lima and Ica under the decentralized scenario, and the appearance of consumption hubs in Chimbote and Arequipa/Ilo. The construction of a gas pipeline to the Northern part of the country, extending the projected gas pipeline to Chimbote, will make it possible to connect Northwest⁵⁶ gas reserves to the gas distribution network system.

Figure 12: Comparison of Centralized and Decentralized System, 2028 (MMCFD)
(Transportation volumes shown in MMCFD)



Source: Authors preparation based on PRH 2007 and data collected during the mission

71. The decentralized scenario requires a higher level of natural gas reserves. In the Centralized Scenario, accumulated demand in 20 years is 6.66 Tcf, 73 percent of available reserves, after subtracting reserves already committed for the export market. The Decentralized Scenario assumes that over a 20-year period, a total of 7.33 Tcf will be required, representing 80 percent of available reserves. In other words, the decentralized scenario would consume 7 percent more gas (0.67 Tcf) than the centralized scenario. Based on information collected during consultations for the study, including new estimates for the internal demand, total gas usage is expected to reach 1,000 MMCFD in 2012 and 2,000 MMCFD in 20 years. This new scenario will require around 9.0 Tcf of reserves, that is, 100 percent of the reserves available in Camisea's Block 88.⁵⁷

72. Table 3 shows the key differences in both scenarios identifying variations by service zones. It logically notes the lower consumption concentrated in Lima and Ica, and the appearance of consumption hubs in Chimbote and Arequipa/Ilo.

⁵⁶ Later, the gas reserves of Aguaytía and the Central Selva may also be connected. To facilitate the start-up of this system, it would be useful to study the possibility of using Camisea gas reserves to cover peak demand, thus assuring a market for potential developments of reserves in the Northern region and offshore.

⁵⁷ Details on this scenario are presented in a background paper called *Transport Pricing Alternatives under a Possible Decentralized Scenario*.

Table 3: Comparison of Centralized and Decentralized Scenarios (Year 2028)

REGION	Centralized		Decentralized	
	MMCFD	Share (%)	MMCFD	Share (%)
Lima-Callao	960	72%	490	34%
Pisco-Ica	223	17%	73	5%
Cusco-Combapata	106	8%	106	7%
Arequipa-Ilo	0	0%	429	30%
Junin-Ayacucho	48	4%	48	3%
Chimbote	0	0%	294	20%
TOTAL	1337	100%	1440	100%

Source: Authors estimates based on PRH 2007 and sources collected during missions

73. Regional gas pipelines typically have the following features: (i) there is a significant need for financing in the early years, since it will take some time to develop the pipeline; (ii) demands for gas to convert from other non-industrial uses or for thermal energy generation are insufficient to make the investment project profitable and for gas to be sufficiently competitive; (iii) consequently, there must be significant demand in the early years, an anchor demand, such as that corresponding to thermal plants in regions or industries that use gas intensively, and various petrochemical endeavors; and (iv) to replace or complement the above, there must be a tariff scheme that includes subsidies or transfers at the regional or national level, between users and sectors, among others.

74. The *Principal Network Guarantee* (GRP) has been a successful mechanism used in Peru to generate revenue for gas transport infrastructure in the early stages of development. As the market develops and the consumption of natural gas increases, it is likely that the GRP will not be needed for the Camisea-Lima pipeline. The experience with this financing mechanism should be considered for financing regional pipelines for which in the short term there is insufficient demand to fully utilize the pipeline capacity. Regional power projects making use of piped gas should be carefully assessed to ensure that they are competitive with other power projects and do not adversely affect electricity tariffs. Another option for financing the needed expansion of natural gas transport and distribution infrastructure is to consider the reinvestment of corporate and revenue taxes by the mining sector, power sector, and even the natural gas sector itself. In contrast to the GRP used for the Camisea pipeline, the Ica-Marcona pipeline has used a concession structured as a distribution business with a novel tariff design.

75. Under the decentralized plan, natural gas would be transported to the power stations using a tariff system in which the difference between the real tariff and the promotional tariff used today will be paid by electricity consumers. It is not yet clear how under the framework of a standard tariff proposed by the Government, the sites for the power plants in the targeted regions will be selected. Because some consumer locations, such as the South, are very far from natural gas production centers, the tariffs for these subsystems would be high compared to others that are closer, if tariffs are calculated by distance. Conversely, localities far from production centers benefit when tariffs are fixed or “postal” for each subsystem. However, aiming to achieve uniform tariffs for all locations supplied means that important studies of costs, and tariff levels and structures need to be carried out. If the intention of the GoP is to implement a tariff policy with

uniform prices at delivery points (identical value at city gate), the result for both the centralized and decentralized scenarios is that transport tariffs should also be complemented by subsidies or another type of transfer to recover service provision costs. With the current natural gas prices, the decentralized scenario would require a transport subsidy equivalent to 27 percent of the total investment.

76. New gas transportation projects should be structured so as to allow the private sector to assume a reasonable risk in order to invest in infrastructure and recover such investments during the life of the concessions. The private sector has shown a strong interest in bidding on concessions for certain transport routes that the Government had opened for bid, such as in the case of the Sierra natural gas pipeline. However, questions that have been raised by the Government and private developers have been: (a) whether the scope of these projects has been adjusted to regional needs, to the GoP's regionalization policies, and whether the GoP should play a more active role; and (b) whether projects have adequate financing in light of the low level of the initial market. These questions have to be answered before the definition of a medium-term (at least five years) and long-term plan for the development of the sector and of gas transportation infrastructure development policy is adopted.

77. Based on preliminary information collected on regional projects consistent with the decentralized scenario, there are likely to be high infrastructure costs associated with new pipelines, since there are large forest and mountain zones in which the pipelines will pass, with some portions of the routes in socially and environmentally sensitive areas. An additional issue is the increase in the prices of materials in parallel with the international trend. For all these projects, significant demands may arise, provided that gas consumption for electricity, petrochemicals, or mining is consolidated. If major anchor demands do not materialize, the transport tariffs are likely to change substantially. For example, in preliminary estimates of the transport cost for the Sierra Gas Pipeline (Camisea-Cusco-Tacna), if the South's anchor demand (generation and petrochemicals) is excluded from the analysis, the average cost would increase by at least 50 percent.

78. A quantitative exercise to determine the investment needs of the centralized and decentralized scenarios was conducted. Demand was projected for 20 years and transport infrastructure needs were estimated for the two scenarios. Tariff increases for each subsystem (postal for each regional pipeline) are significantly different, as might be expected. Under the centralized scenario, tariffs per subsystem would range from US\$0.50/MMBtu to US\$1.40/MMBtu if costs are fully recovered according to projected demand, and are reduced to US\$0.25/MMBtu to US\$1.06/MMBtu if these are calculated assuming a GRP system in which part of the costs (around 25 percent) are recovered. For the decentralized scenario, the distribution of tariffs is even greater, and is explained by the lesser need to expand the Camisea natural gas pipeline, since the Southern region is supplied by means of a new regional gas pipeline. Costs for subsystems range from US\$0.4/MMBtu to US\$2.4/MMBtu without the GRP and decrease to US\$0.2/MMBtu to US\$1.5/MMBtu with the GRP (table 4). The required counterpart funds for GRP are high and equal about 40 percent of total investment (US\$1,482 MM). In sum, investment

needs in the centralized scenario were estimated to be slightly more than US\$2 billion, while those of the decentralized scenario were found to be 50 to 60 percent higher.

Table 4: Transport Tariffs and Costs under Centralized and Decentralized Transport Scenarios

Delivery Area	Centralized Scenario			Decentralized Scenario		
	Effective demand	Using GRP	Subsidies	Effective demand	Using GRP	Subsidies
	usd/MMBtu	usd/MMBtu	usd MM	usd/MMBtu	usd/MMBtu	usd MM
Lima	1.4	1.2	415	1.3	1.1	224
Ica	1.9	1.6	46	2.2	1.8	28
Junin	2.7	2.1	42	2.6	2.0	42
Sur (Cusco - Ilo)	2.8	2.2	76	2.4	1.5	864
Chimbote	-	-	-	3.0	1.7	323
Average cost	1.7	1.4	579	2.1	1.4	1,482

Note: tariff in delivery point = Tariff in current system (0.92 usd/MMBtu) + fee to finance needed expansions + Tariff by subsystem - estimated (in the decentralized scenario, the delivery point assumes a new pipeline)

Source: Authors estimates

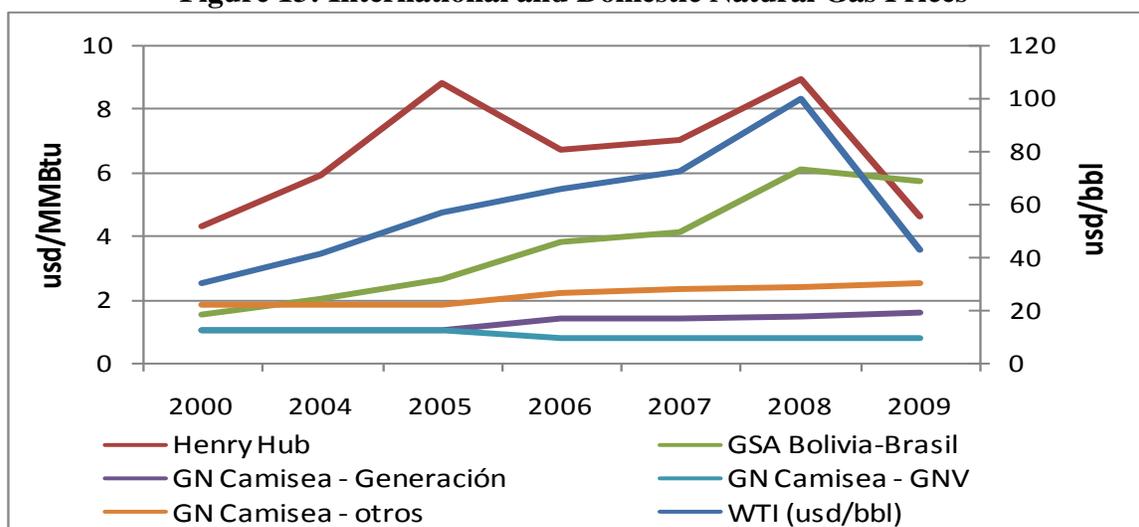
Natural gas pricing

79. Domestic natural gas prices in Peru have been largely uncorrelated with international prices. Figure 13 shows the evolution of international and domestic natural gas (Camisea) prices. It can be observed that domestic gas prices have not been correlated with the rise of international natural gas prices (Henry Hub) or with international oil prices (West Texas Intermediate, WTI).⁵⁸ Since 2004, average prices for natural gas from Camisea have been considerably below the reference prices of other countries in the region, such as the gas sold by Bolivia to Brazil and Argentina. For example, at an international petroleum price (WTI) of 70 US\$/Bbl,⁵⁹ the price of the natural gas for Brazil and Argentina is around 4 to 6 US\$/MMBtu respectively, prices that are two to three times those of natural gas from Camisea. Certainly, relative prices on the domestic markets declined during 2004–2008. The beneficiaries were all those users of liquid fuels that were able to switch to natural gas—electricity users also benefited indirectly. In early 2009, as the global financial crisis spread, international oil and natural gas prices dropped dramatically, with the price of natural gas from Camisea roughly aligned with a WTI price of US\$40 per barrel (Bbl) on average. Oil prices have since risen and are currently between \$70 and \$80/Bbl.

⁵⁸ The Henry Hub is the largest centralized point for natural gas spot and futures trading in the United States.

⁵⁹ The US Department of Energy has forecast the international price of oil at 60 US\$/Bbl for 2009, 80 US\$/Bbl for 2010, and 100 US\$/Bbl in 2013.

Figure 13: International and Domestic Natural Gas Prices



Source: US Department of Energy, MEM

80. An effort to estimate the economic cost of natural gas based on a netback value approach concluded that, for a long-term crude oil price of US\$75 per barrel (Bbl), the netback value of gas for LNG export would be US\$4.4/MMBtu, or roughly twice as much as the current price of gas for power generation. The Government's policy regarding the price of Camisea natural gas is to maintain this promotional internal price at least for the period stipulated in the renegotiated contract with the producers (which allows for no more than a 5 percent increase in the price of natural gas annually, and not larger than the percentage increase of liquid fuels). After this initial period of five years, the annual increases should be lower than the percentage increase of liquid fuels. However, this price policy is exclusive to the initial fields of Camisea (known as blocks 48 and 55) and does not apply to other contract areas in Camisea or in other places.

81. The price of natural gas at the point of generation in Lima and nearby locations is around US\$2.2 per million British Thermal Units (MMBtu). Although the low price of natural gas is translated to a low energy production cost of the thermal plants, electricity users have an additional charge in their bills to pay for the GRP,⁶⁰ which compensates part of the investment cost of the gas pipeline.⁶¹ Table 5 shows the distribution of supply and demand, and conditions of price negotiation, depending on the different block concessions. With the exception of gas produced from Block 88, which is slated for the domestic market, the gas extracted from the remaining blocks 56 and 58 are freely available, meaning that they can be sold to any market, domestic or export. Consistent with the allocation of blocks and markets, there are commitments with ceiling prices by

⁶⁰ Studies for the Camisea gas pipeline indicated unattractively high transport tariffs, due to the expected low demand during initial years of gas production. Investors in the pipeline required the Government to guarantee a minimum capacity usage/payment during the first years of operation. MEM and the regulator designed the GRP as a payment guarantee.

⁶¹ For example, in 2007, the gas transport tariff to pay for the GRP was US\$1.381 per megawatt-month, which is equivalent to approximately US0.245 cents of per kilowatt-hour. The GRP is reaching its termination; therefore, its tariff was reduced considerably in 2008 (about one-fifth of the 2007 GRP tariff).

the Camisea consortium for the commercialization of gas from Block 88, and free market pricing for the remaining blocks.⁶²

Table 5 – Negotiated Conditions for Concession Fields

Block	Contract	Constraint on Supply	Price arrangement (US\$/MMBtu)
Block 88	Exploration	Priority on domestic demand	Price cap domestic market (cap 5-7 percent) Segmentation: Gen.= 1.51; GNV=0.8; other = 1.0 Regional prices: Res. + Gen No SEIN = 0.8; other = 1 Petrochemicals: 3.0 for urea production
Block 56	Exploration	Free disposition Commitment with LNG project	Negotiated between parties (referenced to Henry Hub price) Minimum royalties: 0.5 wellhead (Henry Hub at 3.5)
Block 58	Exploration	Free disposition	Negotiated between parties

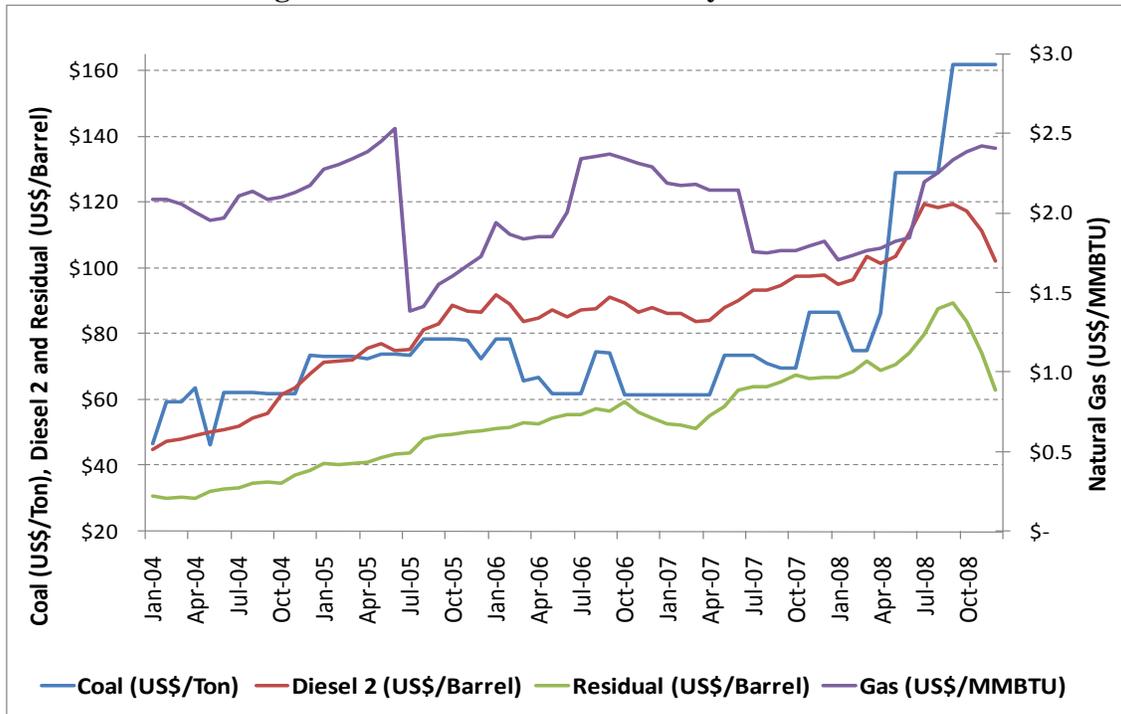
Source: Authors preparation based on contractual conditions of E&P contracts.

82. The role of the price of natural gas in determining the electricity spot price in Peru is marginal. However, this does not mean that the natural gas price plays no role in the spot price, which in turn helps to determine the investment decisions in new power plants. A low natural gas price reduces the rents of all units dispatched when the marginal plant is natural gas-fired. A reduction of the rents in a market where bilateral contracts are not well developed may lead to a shortage of revenues to recover capital expenditures, and thus reduce the incentives for large generation projects to be developed, including hydropower.

83. A more intensive shift to natural gas in the power sector may be expected as long as investors perceive that the support of the authorities of a low price policy for natural gas will continue. Figure 14 shows the evolution of fuel prices used by the system dispatcher when settling revenues. The prices of liquid fuels and coal experienced an upward trend in 2008 (but fell significantly in 2009). For natural gas, the high volatility in the price is explained by the signing of new contracts and the renegotiation of the price agreements. Although there is no clear trend, natural gas prices do not appear to be particularly correlated with the price of substitute fuels.

⁶² These maximum prices are applied to determined regions and for various sectors: the industry and electricity generation.

Figure 14: Fuel Cost for Electricity Generation



Source: Authors estimates based on statistics published by the COES-SINAC

84. As noted previously, the low price of natural gas and the lack of bilateral electricity contracts are contributing to the lack of profitability of hydropower investments. The price of natural gas is not the only limiting factor for investment in hydropower; however, it is certainly an important contributing factor (World Bank 2009). Table 6 shows how the price of natural gas affects investment decisions in hydro and thermal generation. The first column describes a set of investment costs per kilowatt installed in hydro capacity, while the second column estimates the minimum variable remuneration that makes such investment profitable. The third column compares a price for the natural gas -including transport- that equals a combined cycle generation cost with the hydro generation cost (in the second column). The fourth column estimates the wellhead price of natural gas described in the third column after deducting the US\$0.9/MMBtu of transport cost. All figures include taxes but similar results are obtained when taxes are removed. For a natural gas price of US\$1.5/MMBtu (at the wellhead), hydro investment costs above US\$1,500/kW are not profitable compared to an investment in a natural gas combined-cycle plant. In 2008, the regulated price of gas was around US\$1.4/MMBtu and investment in hydro was on the order of US\$2,000/kW or more.

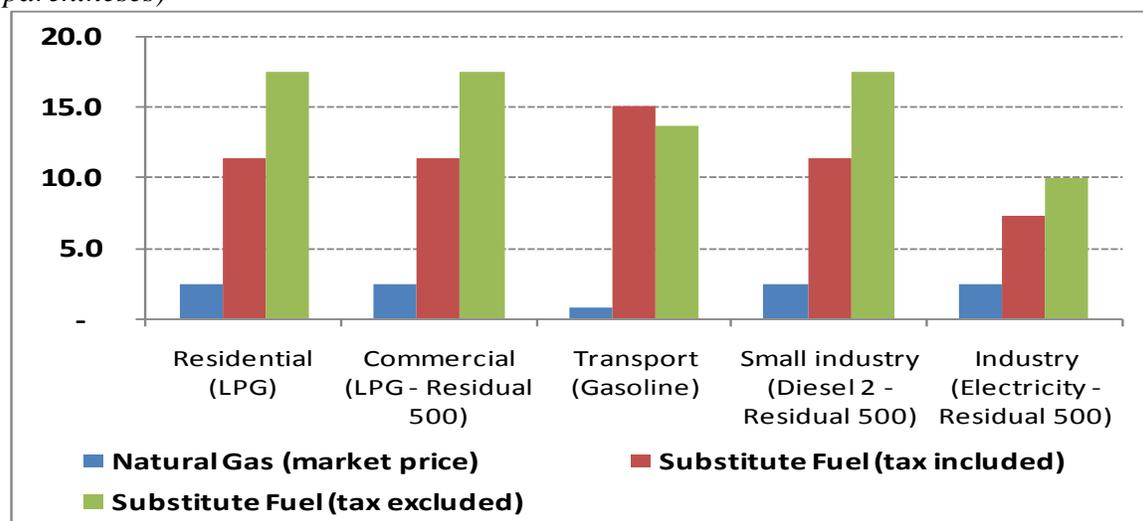
Table 6: Simulated break-even condition between hydropower and a Combined Cycle Generation Investment: The Role of the Natural Gas Price

Hydro Investment	Generation Cost	NG price at Genco	Netback NG
USD /KW	USD /MWh	USD /MMBTU	USD /MMBTU
1,200	29.6	1.4	0.6
1,400	34.1	2.1	1.2
1,500	36.3	2.4	1.5
1,600	38.6	2.7	1.9
1,800	43.1	3.4	2.5
2,000	47.6	4.0	3.2

Source: Authors estimates

85. Beyond the power industry, other sectors are also benefiting from the promotional prices of natural gas. Figure 15 shows the price of natural gas at the wellhead compared to the price of different fuel substitutes. The price of the substitute for each consumer and each type of fuel is obtained by subtracting the costs of transport and distribution of natural gas from the price of the substitute fuel. Thus, the price of the substitute is also priced at the wellhead. In all cases, there are large differences between the price that has to be paid for a substitute fuel and natural gas.

Figure 15: Wellhead Natural Gas Prices and Substitute Cost (Substitute fuel between parentheses)



Source: Authors estimates

86. With such a favorable price of natural gas, those with access to the gas transport network are capturing most of the consumer surplus. However, there are numerous consumers – residential, commercial and industrial – that are not connected to the distribution network. The promotional natural gas price policy benefits those who are connected to the network and appears to have had little effect in increasing the number of new connections.

87. Natural gas is typically produced along with other fuels – such as petroleum and natural gas liquids – whose prices are often closely tied to international prices. Given the profitability of natural gas liquids, especially in light of high international oil prices, producers perceive natural gas as a marginal contribution to their business and have focused on the liquid fuel portion of the business. However, even when the profitability of a hydrocarbon project was due to the existence of high-priced liquids, the other products extracted from the field should not be treated as sub-products, but should be priced at their opportunity cost. Moreover, pricing dry gas at the opportunity cost would create incentives for new exploration and development even when it gas is not associated with liquids. Exploration and production of hydrocarbons in Peru is a private activity, and the question is whether a policy that segments domestic and international markets with price caps in the domestic markets provides sufficient incentive for additional exploration and production contracts. In any case, investors will attempt to focus their activity in the most profitable market, unless regulation prevents them from doing so. In addition, if prices in the domestic market do not provide sufficient returns to justify the involvement in such a risky activity as hydrocarbon exploration and development, investors will be reluctant to participate.

88. The segmentation of the domestic and export markets for gas has and will create tension among suppliers and consumers. The domestic demand for natural gas is being stimulated by the low prices that have been used so far, which means that such demands can only be fulfilled by gas from Camisea. On the basis of currently available data, the economic and financial rate of return for exporting natural gas in Peru is higher than the rate of return from using the gas domestically. An effort to estimate the economic cost of natural gas based on a netback value approach concluded that, for a long-term crude oil price of US\$75 per barrel (Bbl), the netback value of gas for LNG export would be US\$4.4/MMBtu over a 20-year period, or roughly twice as much as the current gas price for power generation.

89. Promotional prices for natural gas have undoubtedly played a positive role in speeding up the development of Peru's domestic natural gas industry. Nonetheless, there will be political and social pressure for gas to be consumed domestically as production expands and to substitute for more costly petroleum fuels. However, the consequences of segmenting the export and domestic markets through a high price differential is likely to have a negative impact on the discovery of new reserves, reduce the attractiveness of natural gas development contracts to private investors, and encourage relative consumption by the domestic markets. New gas exploration and development subject to free availability of gas across domestic and export markets will focus on projects that are more attractive in terms of size and prices than those achieved by current promotional prices in the domestic market. For freely available gas to be allocated to the domestic market, prices need to be attractive. Low gas prices also encourage excess demand, though only to the extent that low-priced gas is available.

90. As the natural gas market develops with more active players in upstream exploration and development, a move towards opportunity cost pricing and a reduction in the segmentation of natural gas markets between domestic and export will benefit the

industry. Assuming that large reserves are confirmed, Peru is likely to become a net gas exporter, while also satisfying the needs of the domestic market. Becoming a net gas exporter does not signify a loss of the country's comparative advantage or create new constraints. On the contrary, price reforms will help to reduce the distortions between the domestic and the international markets. One of the first objectives of economic pricing would be to promote the use of combined-cycle technologies for gas-fired power plants, but this would also affect project size, the hydro-thermal mix, the location of the thermal plants, and the prospects for petrochemical development.

91. A new domestic gas pricing formula could take into account international price references and the value of gas to different types of consumers. Similar adjustments would be needed for the prices (and subsidies) for LPG and diesel, the main substitute fuels of natural gas. Indexing gas prices to international petroleum or gas prices would likely have a significant impact on the speed and type of gas-fired generation constructed, and would also provide additional incentives for investment in hydro. If the increase in gas prices translates into an increase in electricity prices for consumers – assuming that the efficiency increases by moving to combined-cycle plants are not sufficient to offset the price effect – the Government would need to explore options for limiting the impacts on poor households and potential impacts on economic production.

92. To encourage the supply to the domestic market, further diversify the energy matrix, and enable the use of more efficient and renewable technologies, it is advisable to adjust natural gas prices, which could be done gradually to avoid reduce consumer concerns and potential economic impacts during the adjustment period. A strong government commitment to a credible adjustment path will be crucial to reinforce investors' attitudes toward, for example, the development of combined-cycle generation plants and hydroelectric projects. A clear signal on how prices will be determined and the specific adjustment path would be important for all market participants.

V. Conclusions

93. The development of Peru's natural gas industry has helped meet the growth in energy demand over last decade and has led to the successful diversification of the country's energy matrix, especially in the power sector. While the policies adopted by the Government of Peru have served to rapidly expand the natural gas sector, new policies are needed for the future.

94. One of the major objectives of this study is to look at the opportunities to expand the use of gas beyond the power sector. Expanding the use of gas by the industrial, residential and commercial, transport, and petrochemical sectors will require increased clarity on natural gas reserves and the government's energy development plans. Such information is needed to justify the investments in infrastructure and in plant and equipment by downstream users. In addition, investments in gas transmission and distribution infrastructure will also play a major role in determining the future expansion of natural gas consumption.

95. Beyond the power sector, which has been the focus of natural gas use in Peru so far, there are four main sectors that could expand their consumption of natural gas.

- **Industry.** There are major environmental and efficiency benefits of expanding natural gas usage by industry in Peru. Natural gas is an especially important fuel for industries that require a clean fuel source, such as semiconductors, pharmaceuticals, and food. Given the benefits of natural gas, industrial users in Peru are likely to be willing to pay higher netback values (related to the opportunity cost of other fuels), but there also needs to be a consistent and fair pricing policy for natural gas that does not disproportionately favor specific sectors (see pricing discussion below).
- **Residential and Commercial.** The environmental and convenience benefits of piped natural gas are often major reasons for expanding its usage in the residential and commercial sectors. In Peru, the expansion of natural gas in these sectors faces two primary challenges: inadequate upfront financing for consumers and large LPG subsidies. There has recently been progress in solving the first challenge, as the gas supplier in Lima-Callao is providing financing to customers for the initial hookup and for the conversion of appliances. The second challenge is the existence of significant residential subsidies for LPG, especially for middle and high-income consumers, which has reduced the incentive for consumers to switch to piped natural gas. The reform of residential LPG subsidies is a prerequisite for the expansion of piped natural gas, and is likely to have equity and fiscal benefits as well if subsidies to high-income consumers are reduced.
- **Transportation.** The use of natural gas in the transport sector is typically an economical way of reducing urban air pollution associated with vehicular traffic.

Government estimates of potential natural gas demand by the transport sector in Peru would appear to be able to be easily met and are perhaps conservative, even if the transport market is limited to Lima-Callao, which has the vast majority of the country's vehicles. In addition to natural gas pricing, other policy levers to promote the adoption of natural gas vehicles include environmental regulations and tax incentives.

- **Petrochemicals.** Large investments and large gas reserves are typical prerequisites for the development of a petrochemical industry. In Peru, there is a need for further clarity on plans and responsibilities for related infrastructure investments. Presently, and with the exception of the first phase of fertilizer development, petrochemicals would not appear to be the highest-valued use of natural gas in Peru. The prices of petrochemical products in the international market are currently depressed and there are numerous low-cost producers internationally with whom Peru would need to compete to become a producer of basic petrochemicals such as ethylene. Also, since the market for basic petrochemicals would need to extend beyond the domestic market, import-substitution is an insufficient justification for development.

96. In the course of conducting research on the downstream natural gas industry in Peru, a number of key energy sector issues with important policy implications became apparent.

- **Efficiency.** It is possible to significantly improve the efficiency of natural gas-fired power generation in Peru by either increasing the price of natural gas, or by requiring minimum technical specifications for power plant equipment. Nearly one-fifth of Peru's current natural gas consumption could be saved if higher-efficiency combined-cycle technology was universal. Alternatively, the equivalent of nearly two years of new power generating capacity in Peru could be provided through the use of combined-cycle instead of open-cycle technology.
- **Integrated Energy Planning.** The rational use of natural gas and other fuels for power generation could be facilitated in Peru through more integrated long-term planning. This could be facilitated through the creation of a government planning unit with the technical know-how to link the objectives of the government with those of private investors. A key task for such a unit would be to develop policies and regulations that are consistent with the GoP's overall objectives for hydrocarbons, electricity, and renewable energy.
- **Infrastructure Requirements of Decentralization.** The debate in Peru over "centralized" versus "decentralized" development of the natural gas and electric power systems has not adequately factored in the infrastructure investments that would be required. While decentralization would likely provide a more balanced industrial and power development and improve energy security, it will also require significant investment in infrastructure that may not be immediately forthcoming from the private sector given the various risks (inadequate demand,

regulatory uncertainty). A key factor for private investment will be to have clear natural gas reserve and demand estimations and a gas transportation plan for medium- and long-term supply, as well as an appropriate tariff scheme and financial structure to stimulate the development of transport infrastructure.

- **Natural Gas Pricing.** Current pricing and regulatory policies for natural gas are hindering the Government's objective of promoting the development of hydroelectricity and other renewable energy technologies. To level the playing field between natural gas and hydroelectric plants will require a price of gas between \$3.50 and \$4.00/MMBtu, compared to the current price of around \$1.50/MMBtu. In addition, to provide a market incentive for the use of higher efficiency combined-cycle power plants will require an increase in current natural gas prices of between \$0.50 and \$1.00/MMBtu (to \$2.0 to \$2.5/MMBtu). If domestic natural gas prices remain consistently well below international market prices, there will be little incentive for private producers to supply the domestic market. There are also likely to be continuing conflicts between domestic users that are paying different prices for natural gas.

97. The natural gas industry in Peru is young and has rapidly transformed and diversified the energy matrix in the country. While preferential policies for natural gas have been successful in launching the natural gas industry, new policies and a more active role of the Government are needed to expand the natural gas sector within the overall energy and development objectives of Peru.

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