THE HYDROCARBONS INDUSTRY IN PERU

Report prepared for the Instituto de Estudios Superiores de Administración – IESA

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1. INTRODUCTION

The Peruvian productive sectors experienced major changes during the 1990s. In that decade a privatization process began and most of the state-owned companies and government assets were transferred to the private sector. The hydrocarbons sector was not an exception. The state-owned PETROPERU was privatized and most of its assets were transferred to the private sector. The privatization scheme was aimed to promote competition and eliminate barriers to access in the industry. Thus, the new market structure of the Peruvian hydrocarbons sector is completely different to the vertically integrated and monopolistic structure found in industries controlled by state-owned firms. Although there are clear leaders in the industry, there is a vast amount of firms that are taking place in different upstream and downstream activities.

After a decade, the results of the privatization process are still taking place. Besides the discovery and launch of Camisea, the increase of exploration and exploitation contracts signed between private firms, international and domestic, and the Peruvian government are only in the last two years showing some favourable results. The recent discoveries of oil in the jungle and the Talara Basin and those of gas in the Marañon Basin are attracting new investors who are becoming interested in the under explored regions available in Peru, as well as lured by the increasing hydrocarbons prices and the incentives granted by the Peruvian government.

However, Peru is still far away of becoming self-sufficient in hydrocarbons. It is expected that in 2009, the country will turn into a net oil exporting country. This would be accomplished by an increase in production but also by a change in the energetic matrix that will decrease the country's dependence on oil. The shaping of the Camisea gas internal demand is crucial to reach this goal.

Although the Peruvian legislation is reckoned to promote private investment, it is still incomplete in terms of distributing the benefits of the hydrocarbons activities among the different stakeholders such as the government itself, the regions that host these activities and the consumers. For example, special attention should be given to the regulation and government take from downstream activities. The challenge is to adjust the current legislation without jeopardizing judiciary stability.

This paper is organized in eight sections. The second one describes the Peruvian hydrocarbons sector evolution. It reviews the evolution of production, reserves, investment, domestic demand and exports. The third one analyses the institutional framework emphasising the investment promotion measures, the nature of contracts and the distribution of rents, as well as the competition framework that rules the sector. The fourth section depicts the main domestic actors that participate in the upstream and downstream activities. The fifth section illustrates the geological and prices factors that are influencing exploration activities in Peru. The sixth section depicts the main technological changes that transformed the hydrocarbons industry and how technological change is adopted in Peru. The seventh section discusses the different impacts of the Camisea gas discovery. Finally, some conclusions and recommendations are drawn.

2. SECTOR'S EVOLUTION

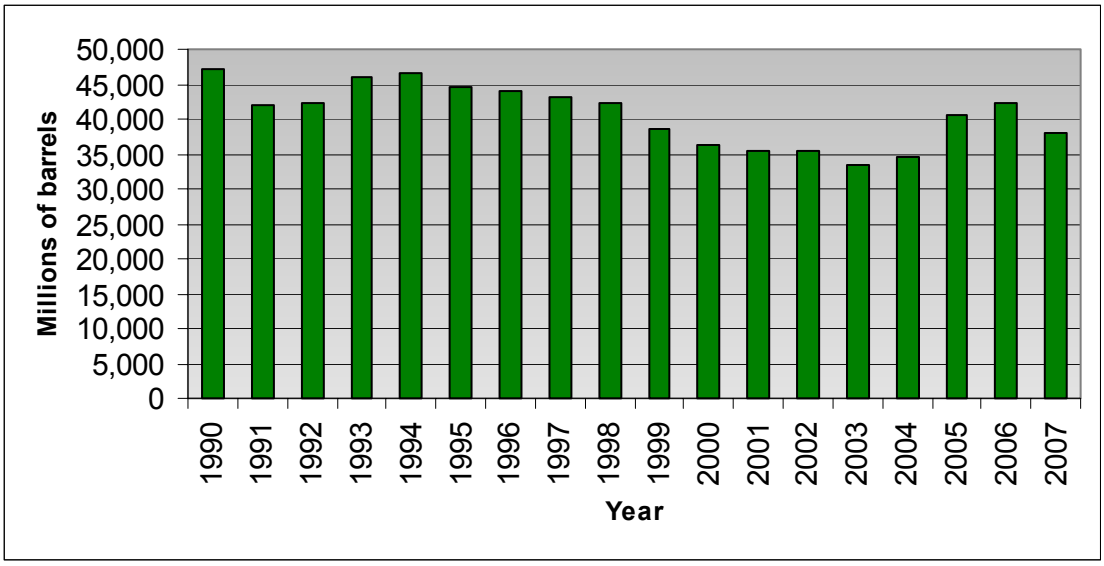
Production

Compared to other countries in Latin America, Peru is a small oil producing country. During the late 1970s and 1980s, after the nationalization of major oil fields, the state-owned company PETROPERU made the discovery of the Trompeteros oil field in the Marañon Basin that marked an important increase in oil output. After 1980, oil reserves began to decline due to several factors such as: unsuccessful exploration efforts, decrease of investment levels and the inability to take advantage of economies of scale due to the disperse locations of the oil fields (OSINERG, 2005).

Figure 1 shows that during the first half of the 1990s, oil production averaged around 44,000 millions of barrels per year. Despite the privatization of PETROPERU in the early 1990s and the increase of exploration investment, production had a declining trend between 1995 and 2003, with an average output of 39,000 millions of barrels per year. This declining trend is reverted in 2004, when output begins to increase at an annual rate of 7%, reaching a production of 42,000 millions of barrels in 2006. However, the current level of production and the increasing internal demand obliges the country to import oil.

Figure 1

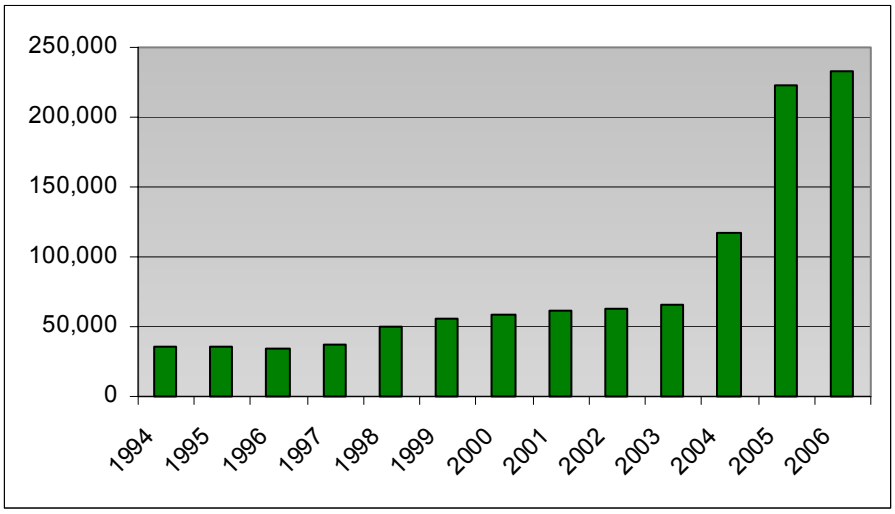
Perú Annual Oil Production
1990-2007
(In millions of barrels)



Source: Ministerio de Energía y Minas

This meager performance of the Peruvian hydrocarbon's sector is changing due to late discoveries and launch of new natural gas deposits. The discovery of Camisea in the late 1980's, a deposit with reserves of around13 million cubic feet, opened the possibility for Peru to become a self-sufficient hydrocarbons country. In fact, **Figure 2** shows the sharp increase of gas production since 2004, year in which the Camisea gas field began its operation. Gas production went up from 65.9 millions of cubic feet in 2003 to 232.3 millions of cubic feet in 2006.

Figure 2
Perú Annual Natural Gas Production
1994-2006
(In millions of barrels)

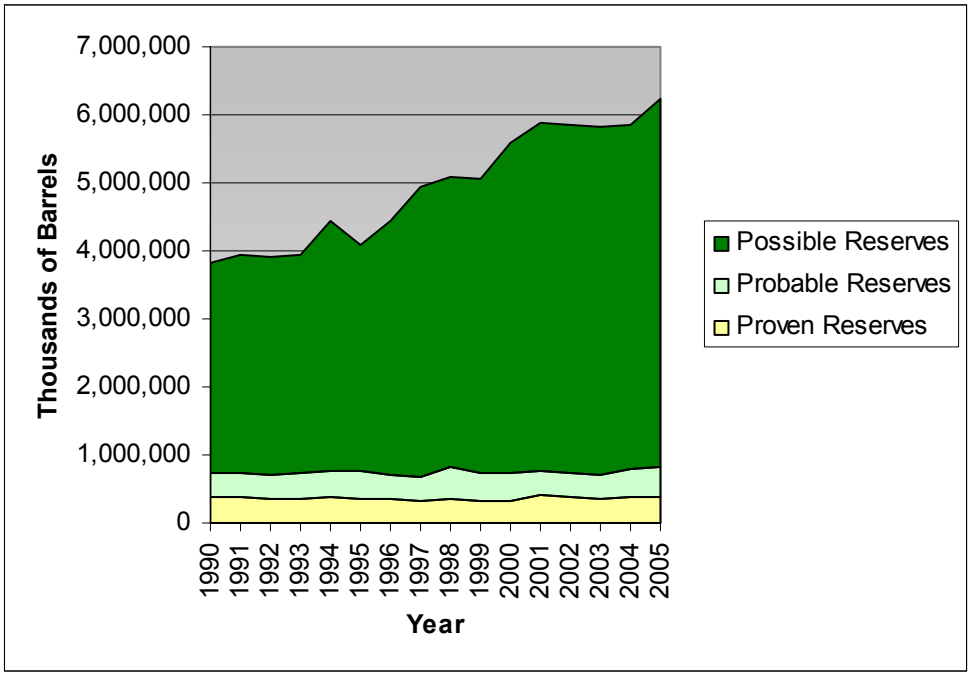


Source: Ministerio de Energía y Minas

Reserves

Despite the drastic reforms taken place in the mid 1990s, which transformed the investment conditions in the Peruvian hydrocarbons' sector, proven and probable reserves remained stagnated at a level of 382 millions of barrels (the same level reached in 1990) and 438 millions of barrels, respectively (see **Figure 3**). However, there has been a major increase in possible reserves, which increase from 3,102 in 1990 to 5,418 millions of barrels in 2005.

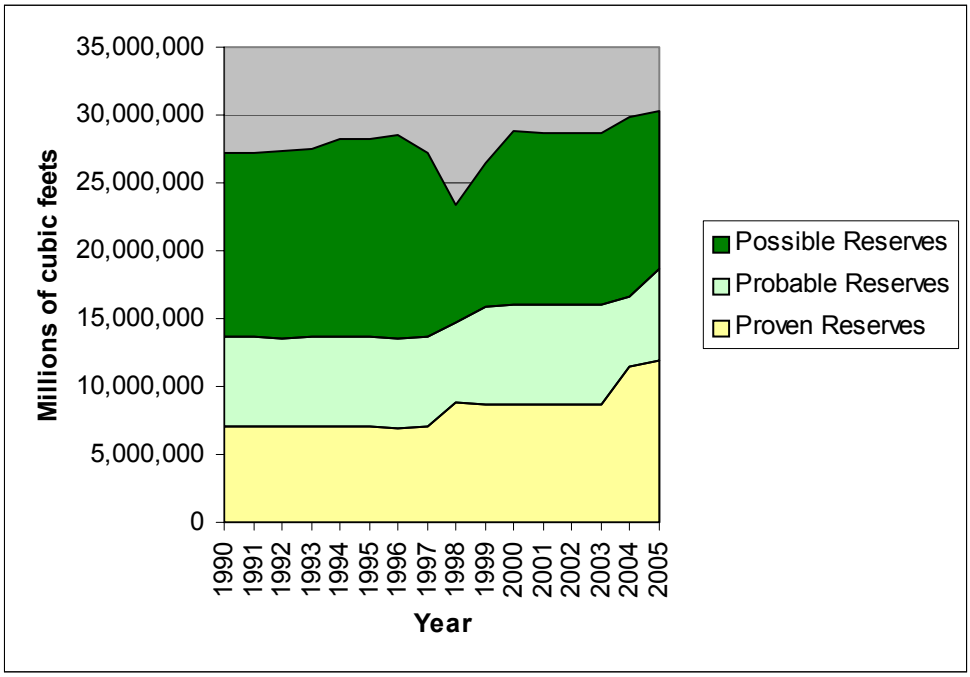
Figure 3
Crude oil reserves (MB)



However, the increase in possible reserves only indicates that there is a 10% of certainty that these reserves would be produced. Thus, to estimate a proxy for the depletion rate, it will be necessary to use the ratio production between proven reserves, given that the latter show a 80% to 90% of being produced. This ratio remained around 12% during all the 1990s, while it reduced to 9% for the period 2001-2004 and, finally, it increased to 11% in 2005.

On the other hand, natural gas proven reserves increased, thanks to the Camisea discovery, almost 70% in the period 1990-2005, increasing from 7,705 to 11,927 millions of cubic feet (see **Figure 4**). The challenge that is facing the Peruvian government is how to attract investment in the downstream industries and to promote domestic demand. At present, there is a compromise to produce for the domestic market but the attractiveness of exporting gas is very tempting. Anyhow, the current ratio gas production between proven reserves barely reaches 2%. This ratio will increase when the LNG plant in Pampa Melchorita will be finished as well as the infrastructure to distribute gas to Lima.

Figure 4
Perú Natural Gas Reserves
1990-2005
(In millions of cubic feets)



Source: Ministerio de Energía y Minas

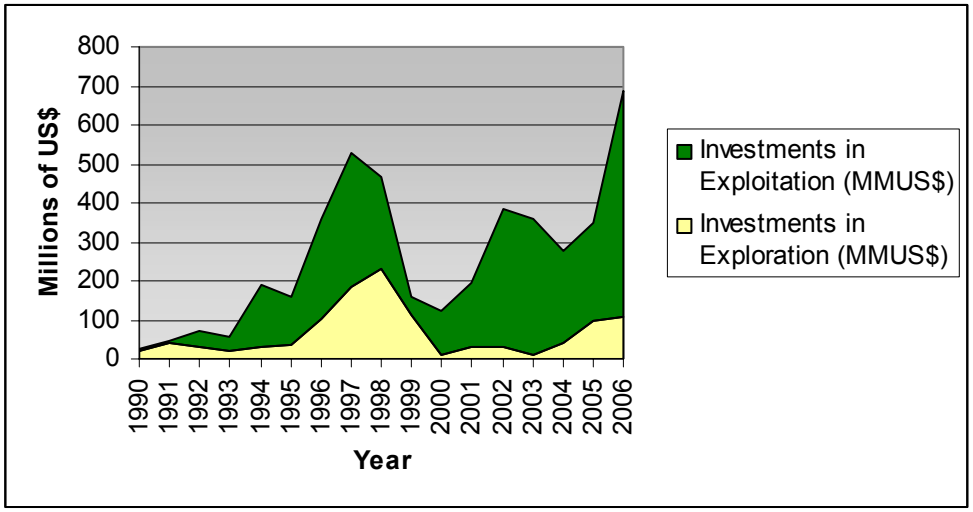
Investment

After the privatization process, investment levels began to increase steadily. As it is shown in **Figure 5**, investment in exploration increased from US$ 19 million in 1990 to US$ 108 million in 2006, while investment in exploitation augmented from US$ 5 million to US$ 581 million in the same period. The rapid increase in exploitation investment responded to the compromises agreed by the privatization contracts in existing oil fields.

Figure 5 also shows that investment reached a peak in 1997, amounting US$ 528 millions, to decrease to US$ 125 million in 2000. This reduction reflected, with a certain lag, changes in oil prices, which diminished from US$ 20 per barrel in 1990 to US$ 11 in 1998. Investment levels recovered in 2001, reaching US$ 196 million while prices went up to US$ 27 per barrel in 2000.

Figure 5

Peru Annual Investment in Hydrocarbons Exploration and Exploitaition
1990-2006
(In millions of US Dollars)

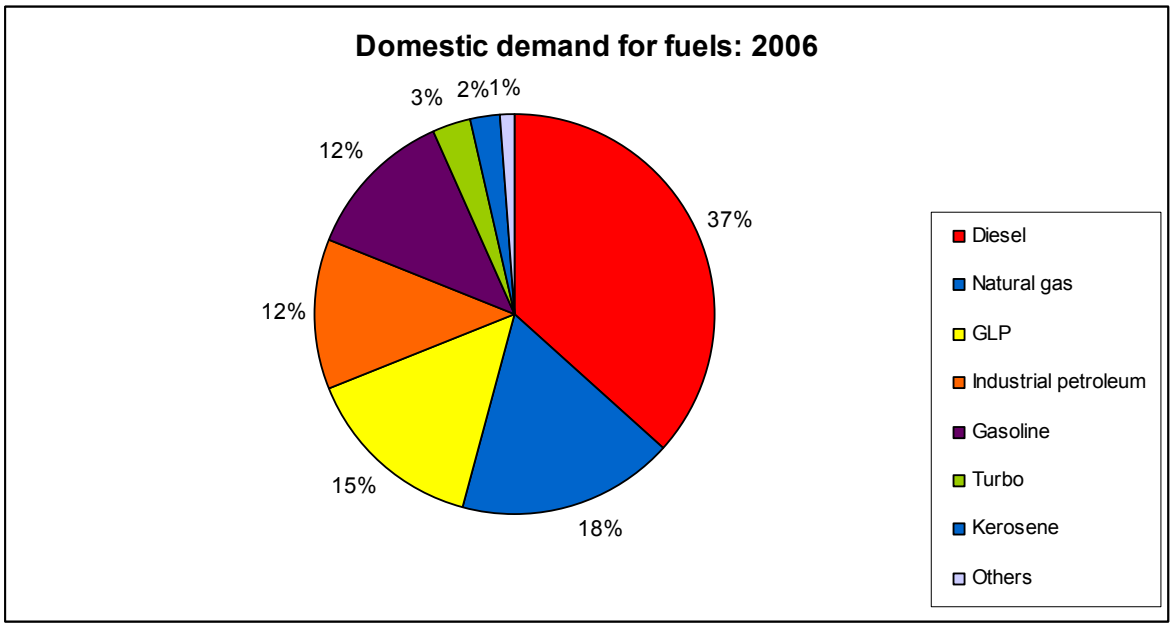


Source: Ministerio de Energía y Minas

Domestic demand of fuels

In 2006 the domestic demand for fuels was around 164 thousands of barrels. **Figure 6** shows that almost 70% of all demand is related to diesel and gas. Diesel (37%) is consumed basically by the transportation sector. Diesel demand has almost doubled since 1993, basically by the increase in vehicles, most of which were second hand. The consumption of gas, also experienced a major increase because of the substitution as an energy source in the industrial sector and to a lesser extent to the increasing demand for the transportation sector. In 2006, natural gas and LGP comprised 33% of all demand. In the domestic sector, LGP has substituted the use of kerosene that only represents 1% of demand while in 1993 it represented 13%.

Figure 6



Source: Ministerio de Energía y Minas

Exports

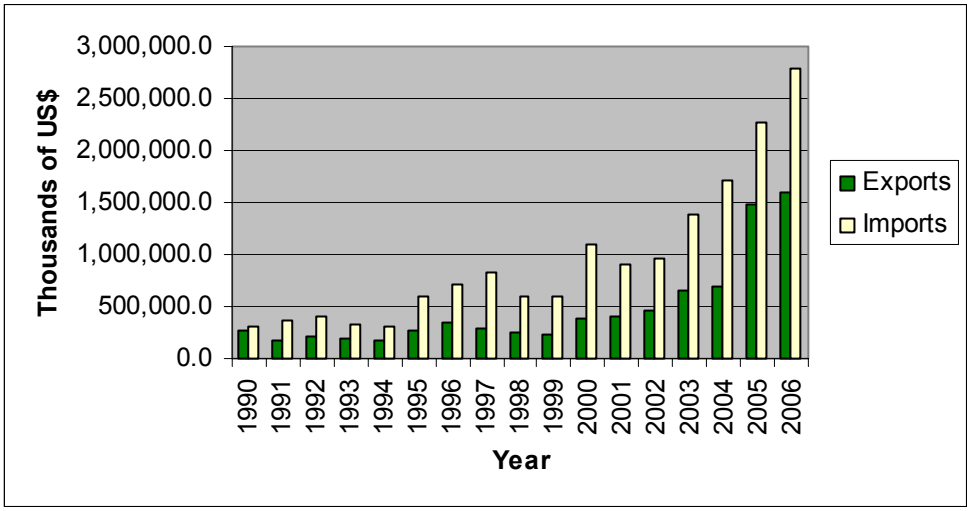
Peru imports hydrocarbons to satisfy its domestic demand. However, it exports crude oil and some hydrocarbon products. The reason is that Peruvian crude oil is heavy (lower than 22 API[1] gravity). Thus, the country exports crude oil and imports light oil to produce products such as high octane gasoline, kerosene and Turbo A-1.

As shown in **Figure 7**, since 1990 Peru has been a net hydrocarbons importer. In that year, the deficit was around US$ 52.5 millions. This deficit has increased since domestic demand augmented, reaching a maximum of US$ 1,184 millions in 2006.

It is expected that hydrocarbon exports associated to the Camisea project, around year 2009, will revert this deficit. However, estimates of the Vice Ministry of Hydrocarbons indicate that the country will continue to be a crude net importer till 2011.

[1] API stands for American Petroleum Institute. API gravity is a measure of how heavy or light petroleum liquid is compared to water. If its API gravity is higher than 10, then the petroleum liquid floats on water. However, this indicator serves to measure the relative density of petroleum liquids. Light crude oil has an API higher than 31.1 API. Medium crude oil has an API between 22.3 and 31.1 API. Crude oil is considered heavy when its API is lower than 22.3.

Figure 7
Peru Annual Hydrocarbons Trade Balance
1990-2006
(In thousands of US$)



Source: Ministerio de Energía y Minas

3. INSTITUTIONAL FRAMEWORK

Background of oil regulation in Peru

Before the 1990s, Peru was a small oil-producing country with a major state-owned oil company. Although foreign contractor companies were operating in Peru, the state-owned PETROPERU, was engaged in all the phases of the oil business and held the monopoly in the sector.

The international market conditions and the lack of financial independence of PETROPERU resulted in a sustained decreased of investment in the Peruvian oil sector. In the period 1980-1989, PETROPERU's annual investments reached US$ 202.3 millions (in 1995 US$ dollars) while foreign contractors' investment was US$ 77 million, but in the period 1990-1993 PETROPERU's figures were only US$ 52 million and those of foreign contracts were US$ 37 million.

This situation that affected reserves and domestic production ended up in a secular negative hydrocarbons trade balance from 1987. In addition, the macroeconomic imbalances suffered by the country during the 1980s together with this vulnerability of the hydrocarbons' sector led in the 1990s to a major set of reforms with the purpose of promoting private investment and reverse the dependence on imported oil.

Current regulation setting[2]

In the beginning of the 1990s, a macroeconomic stabilization program and major structural reforms took place. The extractive sector, that includes hydrocarbons and mining, experienced major changes in their regulation.

Several pieces of legislation were promulgated to promote private and foreign investment. Those were the cases of the Legislative Decree No. 662 (January 1991), which promotes and protects foreign investment in all the economic sectors, and the Legislative Decree No. 757 (November 1991), which guarantees free initiative and private investments. The latter also eliminates the preferences granted to the state to exploit natural resources or to participate in economic activities at the expense of private initiative. It also allows for tax stability agreements between the state and private firms.

At the same time, the Peruvian Congress ratified the subscription of the Convention Establishing the Multilateral Investment Guaranty Agency (MIGA), as well as the Convention establishing the International Center for Settlement of Investment Disputes (ICSD). In 1992, the Peruvian Government signed with the United States a Financial Agreement on Incentives to Investment, allowing the Overseas Private Investment Corporation (OPIC) to issue insurances, re-insurances or guarantees to cover US investments in Peru.

The previous decrees provided a favourable framework to promote a major reform in the hydrocarbons sector. In 1993 was promulgated the Organic Law for Hydrocarbons (Law No. 26221), which promoted the development of economic activities in this sector based on free competition and elimination of economic barriers.

The Law No. 26221 brought about important changes in the upstream activities, such as:

- While the state maintains the property of in situ hydrocarbons, it grants the ownership of the hydrocarbons extracted to the contractor. This means that contractors are not obliged to sell the hydrocarbons to the state. Output can be exported and contractors will only be obliged to satisfy domestic demand in case of national emergency.

- Longer term contracts: up till 7 years for exploration and up till 30 years for oil exploitation and 40 years for gas exploitation.

- Contractors' obligations in the exploration phase are reduced, especially with regards to the wildcat drilling.

- Contract area with no specific maximum size, it only depends on the exploration program.

- Contractor revenues are based on production valued at international prices, estimated using a crude oils basket.

With regards to government take and taxes, Law No. 26221 establishes that:

- Government take is reduced from 50% to a negotiable percentage that ranges between 15% and 35%[3].

[2] For a more detailed description of the regulatory framework, see Campodónico (1999) and ESMAP (1999).

- Royalties are paid in cash based on the fiscalized hydrocarbons production[4] and the international prices. In case that royalties are not paid by the contractor, the state may retain without previous notice the volume of production to cover the royalty.

- No taxes and customs tariffs are paid during the exploration phase.

- Income tax is determined by the general tax rules (30%).

- Profits based on a royalties' function of the R factor (ratio of accumulated income to cumulated expenses). **Table 1** shows the schedule of minimum royalties as a percentage of hydrocarbons production. As it can be appreciated, the maximum royalty tier is 35%, however, it is estimated that in average royalties range between 20% and 25% of gross production value (Campodónico, 2007).

Table 1

R factor	Minimum royalty (% of production)
From 0.0 to 1.0	15
From 1.0 to 1.5	20
From 1.5 to 2.0	25
More than 2.0	35

The Organic Law of Hydrocarbons brought about the following changes in downstream operations:

- Participation of private firms (foreign and domestic) in any phase of downstream operations as long as they fulfill government requirements.

- Any private firm can import hydrocarbons. Taxes applicable to such imports are at the importers account.

- The activities and prices related to crude oil and by-products are ruled by supply and demand.

- The supply of natural gas through a pipeline is considered a public service, thus the Ministry of Energy and Mines will grant concessions to firms that demonstrate technical and financial capability.

Upstream contracts and hydrocarbons rent

As it will be explained later, PERUPETRO is the state-owned company that represents the hydrocarbons interests of the Peruvian State. Private investors will sign contracts with PERUPETRO in order to perform hydrocarbons activities in the country.

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[3] As it will be noted later, the royalties agreed in the Camisea project are 37.24%. This higher percentage is due to the fact that the current contractor did not bear exploration expenditures, which were previously made by Shell.

[4] Fiscalized hydrocarbons production is the amount of hydrocarbons originated in a certain area, produced and measured under the conditions set by each contract.

The conditions of such contracts define the amount of the hydrocarbons rent appropriated by the Peruvian government and the contractor firm. Under the current law, the private contractor can dispose freely of the rent and profits obtained from its activity while the Peruvian State has defined a set of rules to distribute part of its rent among the regional and local jurisdictions where the hydrocarbons activities are taking place.

Types of upstream hydrocarbons contracts

There are two main types of contracts: services contracts and licensing contracts. In addition, PERUPETRO can grant technical evaluation agreements to promote exploration.

a. Services contracts

In this kind of contract, the private contractor offers PERUPETRO the service of extracting the hydrocarbons, which will be given to the state company. The payment of this service is calculated based on a unit extraction fee that takes into account the international prices. The contractor should be able to cover its investment and operation costs and generate profits. Under this scheme PERUPETRO owns all the production and it is in charged of its commercialization.

b. Licensing contracts

Under this kind of contract, the private company takes all the risks associated with the exploration, development and exploitation of hydrocarbons operations. Once production has taken place the private company owns the hydrocarbons and has to pay a cash royalty to PERUPETRO.

c. Technical evaluation agreement

This kind of agreement gives the contractor the right to conduct technical evaluations of the areas under such agreements and to enter into license contracts if the evaluation indicates that there is potential for profitable operations. The agreements are generally granted for a period of 24 months.

Types of duties applied to the hydrocarbons rent

a. Royalties

Royalties are paid as a percentage of the gross value of the fiscalized hydrocarbons output. Royalties are a policy instrument that helps to attract investment to the sector: lower and clearly set royalties become incentives for private investors to keep exploring and eventually increase production. On the other hand, royalties define the government take and become the main source of the hydrocarbons revenue.

Peruvian legislation provides two methodologies to calculate royalties[5]. Once hydrocarbons are discovered, the contractor can choose between any of these methodologies but cannot change it after the licensing contract is signed.

[5] The description of the two methodologies was taken from OSINERG (2005).

The first methodology is based on production scale. **Table 2** shows that minimum royalties are set at 5% of fiscalised production and the maximum rate levied is 20%.

Table 2

Level of fiscalised production (MBPCD*)	Royalty (%)
Less than 5	5
Between 5 and 100	5 – 20
More than 100	20

* Thousand of barrels per calendar day

This methodology is very simple to apply and provides the operator with a degree of certainty since it has control over the production. It is also very convenient for the government since it allows calculate immediately the amount of royalties that each company has to pay.

The other methodology is based on economic results. It is calculated according to the following formula:

$$R = R_f + R_v$$

$$R_v = \left[\frac{X_{t-1} - Y_{t-1}}{X_{t-1}}\right] * \left[1 - \left(\frac{1}{1 + (r_{t-1} - FB)}\right)\right] * 100$$

Where:

R_f: is the fix royalty, established in 5%
R_v: is the variable royalty, defined as a percentage
FB: is the base R factor, established in 1.15

The variable royalty is applied when $R_{t-1} \geq 1.15$ and when this belongs to the range 0% < variable royalty < 20%

X_{t-1} : Last year revenues at the moment of calculating the variable royalty
Y_{t-1} : Last year expenses at the moment of calculating the variable royalty
R_{t-1} : Ratio between revenues and expenses since the subscription of the contract till period t-1

Under this methodology, the payment of royalties is calculated twice a year. The first one is done in January, based on information of the revenues and expenditures from January till December of the last year; and the second one is calculated in July, based on the information from July till June of the previous year.

In December 2007, from 17 active exploitation contracts in only 5 of them the second methodology is applied. In the rest of them, the methodology based on the production scale is applied.

In terms of the fiscal income generated by the payment of hydrocarbons royalties, there has been a sharp increase due to the increase in oil prices. As shown in **Table 3**, the payment of royalties has increased from US$ 339 millions in 2004 to US$ 733 millions in 2006.

Table 3
Royalties paid by hydrocarbons' operators: 2004 – 2006
(Thousands of US$)

	2004	2005	2006
Oil royalties	259,027	358,911	445,435
Natural gas royalties	15,528	31,077	40,143
LNG royalties	64,724	199,420	247,201
Condensed hydrocarbons royalties		4	6
Total	**339,283**	**589,414**	**732,779**

Source: PERUPETRO

There are some questions about the royalties' levels. In 2007, some bidders were willing to pay higher rates. For example, Vetra Energy has recently compromised to pay royalties of 60% if it finds oil in Block 25 (El Comercio, 2008a). A scenario of oil prices over the US$ 100 is encouraging firms to pay higher royalties to secure their access to hydrocarbon resources.

Some critics to the government policy on hydrocarbons are questioning if it will be necessary to change the legislation. But the government position is to maintain the status quo. It does want to send the message to investors about the country's judiciary stability and the respect to contracts. However, some experts are suggesting that a revision of all contracts should be done. There is a wide dispersion in the royalties paid by different companies. For example, Unipetro pays US$ 43 per barrel while Petrotech pays only US$ 12.

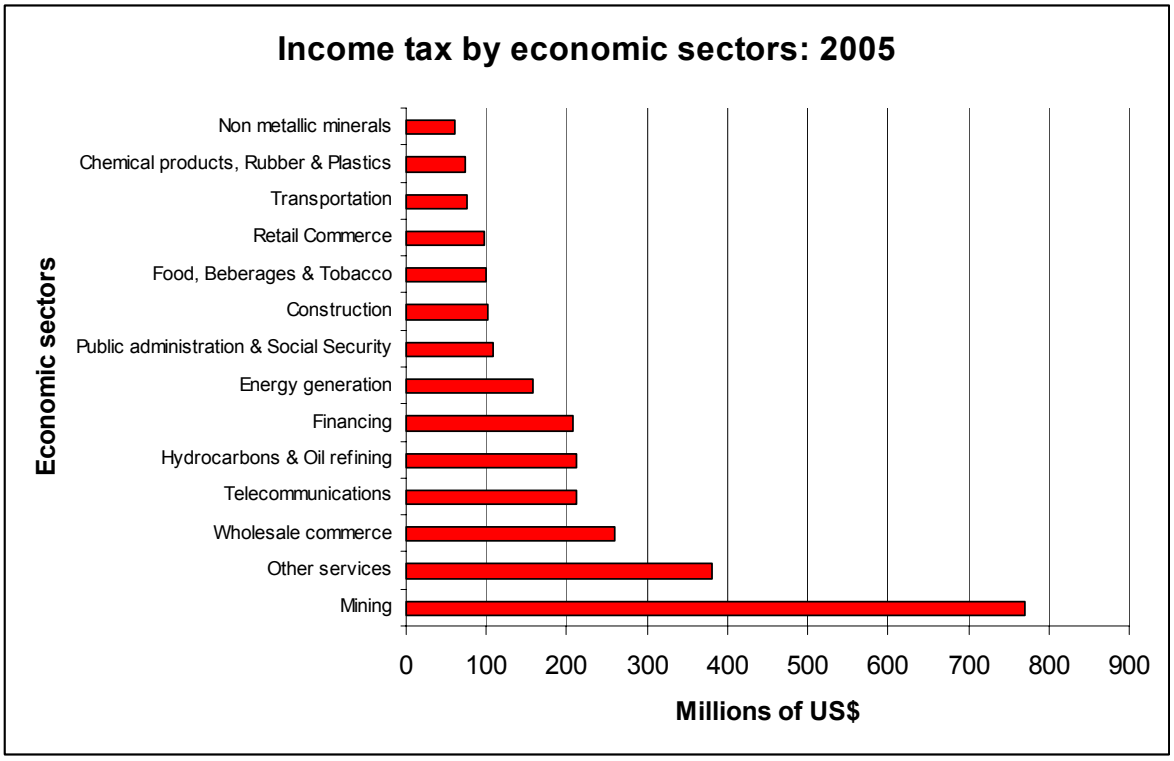
At present, there is no real political pressure urging for these changes. These pressures usually come from regional authorities and interest groups but they are not complaining by now. The reason is that the increase in prices has benefited these regions with more resources coming from the royalties and the canon. The ability to spend is limited so the regions are not eager for more resources. On the other side, the central government is also experiencing a huge fiscal superavit and is also experiencing difficulties in increasing its fiscal expenditure.

Thus, as experts are suggesting it would be wise to use this quiet political environment to analyse the evolution and structure of royalties revenue and to study the possibility of establishing alternative measures to increase government take and a long term hydrocarbons rent fund.

b. Income tax

The general income tax rate is 30% for all economic activities. **Figure 8** shows the ranking of economic sectors regarding its contribution to the 2005 income tax revenues. It can be appreciated that Hydrocarbons ranked in the 5th place after Mining, Other services, Wholesale commerce and Telecommunications. In that year, firms in the Hydrocarbons sector paid US$ 212 million.

Figure 8



Source: Ciudadanos al Día (2006).

Distribution of rents

Royalties paid to the government are distributed among the central government, hydrocarbons-related institutions and regional and local governments where the extractive activities take place.

In the same way, the canon is another contribution distributed among regional and local governments. The canon is defined as "the effective and adequate participation granted to regional and local governments of all revenues and rents obtained by the state as a result of the economic exploitation of natural resources". The general laws that define the different kinds of canon are Laws No. 27506 (Canon Law), No. 28077 and No. 28322 (Modified Canon Laws)[6].

[6] The Canon Law has been modified three times. These modifications show the fight for resources among the central and regional and local governments. The Law No. 27506, promulgated in 2001, indicated that the canon was constituted by the 20% of all revenues and rents perceived by the state as a result of the economic exploitation of natural resources. These resources were distributed as follows: 20% to the local municipalities where the resource is located; 60% to the local and provincial municipalities according to a population density index; and 20% to the regional governments. A national debate was set in place because regional and local governments considered that 20% too low. Another point in the discussion was the distribution percentages among the different jurisdictions. In 2003 the Law No. 28077 attended these complaints. The canon was increased to 50% of all revenues and rents. The distribution percentages were changed to the ones showed in Table xx, but the 25% and 40% distributed to provincial and other local municipalities excluded the district where the resource is located. In addition, the population density index used to distribute the resources among other municipalities was changed to include poverty-related indicators. The latter districts complaint about this exclusion and two years later the Law No. 28322 was promulgated.

In the specific case of the petroleum canon, there is no unique definition but each producing region has a specific contribution. There is a specific law to define the oil canon for each producing region. For example, in the cases of Loreto, Ucayali, Piura and Tumbes the canon is defined as 10% ad-valorem of total production. These regions also receive an additional contribution called sobrecanon, which is established in 2.5% of the oil production value.

Law No. 27506 establishes the creation of a gas canon. This is defined as "50% of the revenues received by the state for concept of the firm's payments of royalties and income tax derived from the upstream activities".

One important aspect about the canon and sobrecanon is how it is distributed among the regions and local government. As opposed to other kind of canons, the oil canon is distributed ad hoc. For example, regional governments receive a participation of 52% in Loreto but only 20% in Ucayali, Piura and Tumbes and the regional government of Huánuco does not receive any contribution because it goes directly to the local governments.

With regards to the gas canon, the distribution is established in the Law No. 28322 and is similar to the distribution set for other extractive industries. **Table 4** shows the distribution percentages among the different regional and local jurisdictions. Within each jurisdiction, resources are distributed according to distribution indexes calculated on the basis of criteria that includes population, unsatisfied basic needs and lack of infrastructure.

Table 4
Distribution of canon among different geographical jurisdictions

Jurisdiction	Percentage (%)
Local municipality where the resource is located	10%
Provincial municipality where the resource is located	25%
Other local municipalities that belong to the region where the resource is located	40%
Regional government	25%

With all the complexities in its calculation, the canon is an important source of income for the producing regions. The increase in the prices of hydrocarbons had an important effect in the total amounts distributed as canon. **Table 5** shows that the total amount of canon has increased in 41% from 2005 to 2007. It is expected that these figures will increase due to ascending trends in hydrocarbons prices. As usual, one aspect of concern is how the regional and local governments will use these resources and if these resources will contribute to economic development.

Table 5
Oil and natural gas canon transferred to regions: 2005 - 2007

	2005	2006	2007
Oil canon	180.8	201.7	240.3
Natural gas canon	91.6	120.1	142.5
Total	**272.4**	**321.8**	**382.8**

Source: Sociedad Nacional de Minería, Petróleo y Energía.

Competition framework

The privatization process of the hydrocarbons sector was aimed at promoting a dynamic and competitive industry. Industries like the hydrocarbons are very amenable to be highly concentrated due to the huge sunk costs and the economies of scale that are associated with them, as well as vertically integrated. In fact, PETROPERU was a monopoly that controlled the exploitation, processing and distribution of hydrocarbons.

The privatization process was designed to reach a competitive market structure. It was expected that the deregulation of markets and openness to international trade will secure the conditions to perfect competition. Thus, the regulatory framework was very relaxed, especially in relation to abuse of dominant position and restrictive practices to competition (Ochoa and Távara, 2007).

The Legislative Decree No. 701 was the first piece of regulation about free competition in the Peruvian legislation. It establishes that the following firms' behaviours constitute abuse of dominant position:

- Unjustified denial to satisfy demand or supply of goods and services
- Application of unequal conditions in commercial relations for equivalent transactions that lead competitors to disadvantaged situations
- Subordination of contracts to the acceptance of supplementary transactions

DL 701 also establishes these practices as restrictive to free competition:

- Direct or indirect agreement regarding price or other commercial conditions among competitors
- Undertaking of market shares or of procuring sources
- Undertaking of production shares
- Undertaking of products' quality when it does not respond to technical standards, national or international, with negative effects for the consumer

However, the National Institute for the Defense and Intellectual Property – INDECOPI, the competition regulatory body, has been very relaxed in overseeing and assessing the previous situations in the hydrocarbons sector, with the consequences of discriminatory prices against domestic consumers and the setting of higher prices than parity export prices (Ochoa and Távara, 2007; Campodónico, 2007).

At present, the Peruvian hydrocarbons sector is extremely concentrated, both in the upstream and downstream segments of the industry. The share of Pluspetrol in the upstream segment is 69% of the domestic hydrocarbons production, while Repsol-YPF that operates La Pampilla refinery controls 55% of the domestic installed capacity.

Ochoa and Távara claim (2007) that the Peruvian hydrocarbons industry operates as an oligopoly and has a high degree of horizontal concentration in various activities. For example, 97% of hydrocarbons refining capacity is concentrated in two firms: one state-owned (i.e. PETROPERU) and a private one (i.e. Repsol). Thus, the market structure for this activity is a mixed duopoly. In terms of gas, there are 4 LNG separation plants but Pluspetrol controls 65% of the production of LPG. It is important to mention that Pluspetrol is the operator of the Camisea project, the major gas operation in the country. The consequences of this structure may lead to a situation of higher prices to be paid by the consumer.

The levels of concentration in the commercialization activities are lower. However, three firms that operate refining plants (i.e. PETROPERU, Repsol and Maple) are also registered as wholesale suppliers. These firms are granted with discounts on the net price charged by their refineries. Furthermore, hydrocarbons products such as gasoline, kerosene and diesel are sold in the stations affiliated to the wholesale distribution chain (Ochoa and Távara, 2007).

It is necessary that the regulation in the hydrocarbons sector becomes more stringent to avoid uncompetitive behaviours that, at the end, affect the welfare of final consumers. In that respect there are some legislative proposals to strengthen INDECOPI and to control fusions and acquisitions.

Deregulation in downstream activities is causing some concerns in a context of rising oil prices. The fact that hydrocarbons belong to the contractor once is extracted impedes any government intervention on the transactions they agree with further downstream operators. The fact is that government take in further downstream activities is not clearly regulated, so there is no way to secure an adequate share of the rents in a context of rising oil prices. For example, windfall earnings in the exportation of Camisea gas are calculated in US$ 15 billion, however there is no a clear estimate of the royalties that the country will receive for these exports. Royalties depend on the gas price at the moment of the export transaction but there is no public information about this price. A recent denounce made by a Mexican politician claims that Repsol will be declaring cumulated gas costs of around US$ 6 billion while the Mexican government would be paying US$ 21 billion, thus Repsol's profit would be US$ 15 billion (La República, 2008b).

4. MAIN DOMESTIC ACTORS

According to the Law No. 26221, the hydrocarbons sector is conformed by a series of public institutions that promote, supervise and regulate its activities, as well as public firms that represent the Peruvian state in production, commercial and legal activities such as PETROPERU and PERUPETRO. On the private side, there are the private contractors that are actually engaged in the upstream and downstream activities.

Regulatory institutions

The main regulatory institutions are the Ministry of Energy and Mines, the Supervisory Agency for Private Investment in Energy and Mining (OSINERGMIN) and the National Institute for the Defense of Competition and Intellectual Property (INDECOPI).

Ministry of Energy and Mines

According to the Law No. 26221, the state is responsible for promoting the development of hydrocarbons activities with the participation of the private sector and according to the principles of a free economy. To pursue this objective the Ministry of Energy and Mines is responsible for designing the hydrocarbons policy as well as for carrying out promotion, regulatory and fiscalization activities.

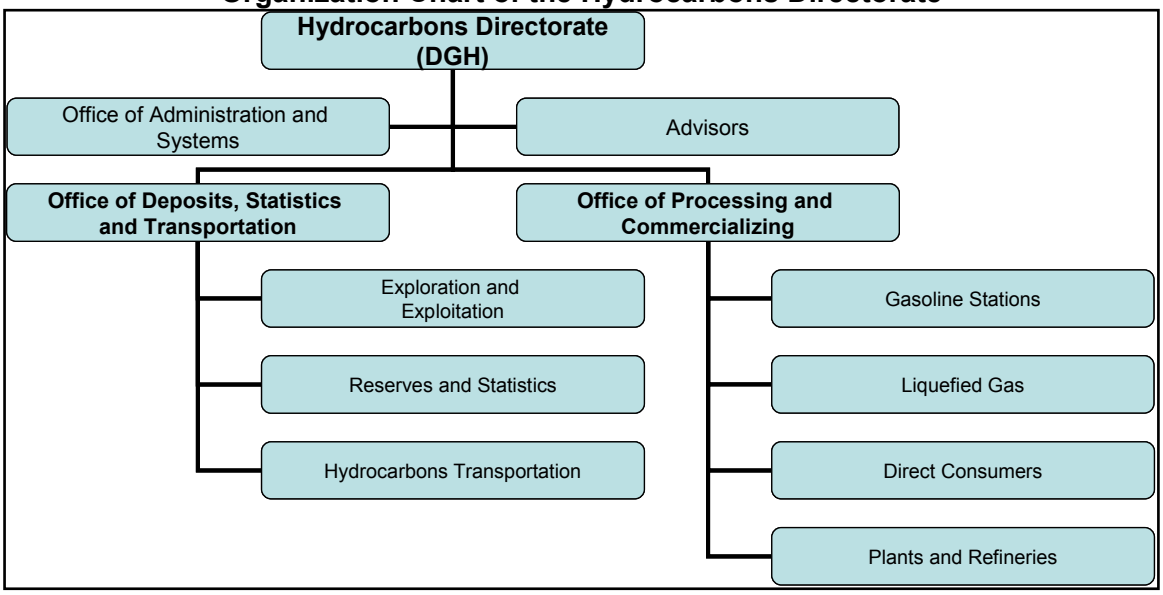
The Ministry of Energy and Mining acts via the Hydrocarbons Directorate (Dirección General de Hidrocarburos – DGH), whose main functions are:

- To keep updated the rules and norms according to the economic and technological changes in the industry.

- To concede authorizations and concessions to private investors.
- To provide information to private investors, users and general public about the procedures and management required for the execution of hydrocarbons activities in the country.

The DGH has a functional design. **Figure 9** shows that there is one office that deals with the upstream activities and transportation (i.e. exploration and exploitation, reserves and statistics, and hydrocarbons transportation) and another office for downstream operations (i.e. gasoline stations, liquefied petroleum gas, direct consumers, and plants and refineries).

Figure 9
Organization Chart of the Hydrocarbons Directorate



Source: Ministry of Energy and Mines

Like other public institutions in Peru, the Ministry of Energy and Mines has begun a decentralization process. The Ministry's regional offices are in charged of supervising the procurement, distribution and commercialization of petroleum products at the regional level.

Supervisory Agency for Private Investment in Energy and Mining

The Supervisory Agency for Private investment in Energy and Mining (OSINERG) is in charge of overseeing the legal and technical aspects of the hydrocarbons activities carried out in the national territory. The specific functions of OSINERG are:

- Oversee for the quality, efficiency and security of the procurement of hydrocarbons.
- Enforce the adequate implementation of the hydrocarbons and natural gas transportation through ducts.
- Secure that consumers have access to the transportation and distribution of natural gas, taking care that the fees are fixed according the law.
- Promote the development, modernization and efficient exploitation of the hydrocarbons procurement.
- Enforce the environmental compliance in the hydrocarbons sector.

- Supervise the fulfillment of investment obligations and other obligations derived from the promotion of private investment.

OSINERG has competences for imposing sanctions to the hydrocarbons entities that fail to fulfill the regulations imposed in the sector, as well as solve controversies among transportation agents of hydrocarbons and natural gas and distributors, commercializing agents or users. It is also required to attend and solve any complaint presented by the users of hydrocarbons against any of the institutions regulated by OSINERG.

During the last years, most of the public action taken by OSINERG has been related to environmental complaints. In special, there have been several environmental accidents related to the duct system of the Camisea project. These frequent accidents have led to an independent international audit of the project.

National Institute for the Defense and Intellectual Property

The National Institute for the Defense and Intellectual Property (INDECOPI) is an institution aimed at protecting the market from monopolistic practices that may result in restrictions and control of competition, as well as from other practices that may lead to unfair competition. INDECOPI also is aimed at protecting the intellectual property rights, the quality of products and others that may have been assigned to it (Decree Law 701, art. 2).

With regards to the regulation of the hydrocarbons market, the role of INDECOPI has been weak due to its institutional fragility and the ample scope of its mandate (ESMAP, 1999). INDECOPI was created in a time where the idea of free, open and deregulated markets was enough to establish a free market regime in the economy. In that sense, the state should only intervene to remove the access barriers to markets (Ochoa and Távara, 2007).

PERUPETRO y PETROPERU

PETROPERU

PETROPERU is the state-owned company dedicated to the transportation, refining and commercialization of hydrocarbons and its derivates. To perform these activities, PETROPERU counts with a large amount of infrastructure, as shown in **Table 6**.

Table 6
PETROPERU's infrastructure

Activity	Infraestructure
Transportation	▪ Northern Peruvian duct ▪ Maritime and fluvial fleet
Refining	▪ Talara refinery ▪ Conchán refinery ▪ Iquitos refinery ▪ El Milagro refinery ▪ Pucallpa refinery
Commercialization	▪ Sales plants ▪ Warehouses in terminals and sales plants ▪ Gas stations

PETROPERU was privatized in the mid 1990s. All of the oil fields were transferred to the private sector and the major La Pampilla refinery (100,000 bbl/d) was sold to the Spanish Repsol. At present, PETROPERU is only engaged in downstream activities.

PERUPETRO

PERUPETRO is a private state-owned company responsible for promoting the investment of hydrocarbons exploration and exploitation in the country. It was created in 1993 by the Law No. 26221. As a state representative, this company negotiates, signs and supervises hydrocarbons contracts and technical evaluation agreements. PERUPETRO is autonomous with regards to economic, financial and administrative issues.

The contracts signed between PERUPETRO and firms from the private sector are ruled by private law and are guaranteed by the ICSID, MIGA and OPIC.

Private upstream and downstream producers

After the privatization process in the hydrocarbons sector, Petroperu transferred all its oil fields to the private sector as well as the largest oil refinery (La Pampilla), a lubricant's plant, the vast majority of its gas stations and some subsidiaries in related activities. This resulted in a complete new market structure, both in the upstream and downstream industries.

Private upstream producers

Table 7 shows there are 12 companies with producing oil fields. The most important of all is the Argentinian Pluspetrol, which accounts for 69% of the domestic hydrocarbons production and operates 3 blocks. The largest one is Block 88, the Camisea natural gas field, which accounts for 30% of all the domestic hydrocarbons production. The other two blocks are oil fields that represent together 39%.

Table 7
2006: Private upstream producers and output

Contractor	Block	Output (barrels)	%
Pluspetrol	88 (NGL)	12,659,101	30.01
Pluspetrol	1 – AB	10,219,175	24.22
Pluspetrol	8	6,207,286	14.71
Petrobras	10	4,648,288	11.02
PetroTech	Z – 2B	4,555,777	10.80
Aguaytía	31 – C (NGL)	1,213,770	2.88
Sapet	VII / VI	1,113,818	2.64
Rio Bravo	IV	414,081	0.98
Mercantile	III	333,145	0.79
GMP	I	282,942	0.57
Petrolera Monterrico	II	209,461	0.50
Maple	31 B/D	174,154	0.41
Unipetro	IX	101,690	0.24
GMP	V	47,079	0.11
Petrolera Monterrico	XV	6,998	0.02
Olympic	XIII	397	0.00
TOTAL		**42,187,162**	**100.00**

Source: PERUPETRO

Other important players, though to a lesser extent, are the Brazilian Petrobras and Petrotech, subsidiary of the US Petrotech International, that control 22% of domestic output (each one 11%).

In general, the regulatory framework has been successful in promoting the investment of the private sector. By the end of 2006, the exploitation contracts were 19 and the exploration ones added 42. The results of exploration have been meager till 2007, when the prospects became more optimistic since the discoveries in the Talara and Marañón Basin and 24 more contracts were signed with investment plans of around US$ 800 million.

Private downstream producers

Downstream activities are divided in transportation, processing, distribution and marketing of hydrocarbons.

a. Transportation

The transportation of hydrocarbons in Peru is done by different means. There are two hydrocarbons pipelines. **Map 1** shows the Oleoducto Nor Peruano as a pipeline of 854 Km. that carries oil from Station 1 (San José de Saramuro) in the northern jungle to the terminal Bayóvar in Piura. It has an annex pipeline (Ramal Norte) of 252 Km. that carries oil from the Andoas Station and join to the main pipeline in Station 5 (Borja). These pipelines carry 70,000 barrels per day.

The Oleoducto Nor Peruano is operated by Petroperú, which has plans for its expansion. The plan is to connect the pipeline with oil fields in Ecuador. This will demand an addidional pipeline of 483 Km (Petroperú, 2007). In addition, perspectives of increasing output from three oil fields (67, 39 and 1 – AB) in the jungle have opened perspectives to export oil to Southeast Asia by 2010. Petroperú is studying the choices of expansion to carry 200,000 barrels daily. Estimates of investment are around US$ 800 million (Andina, 2007).

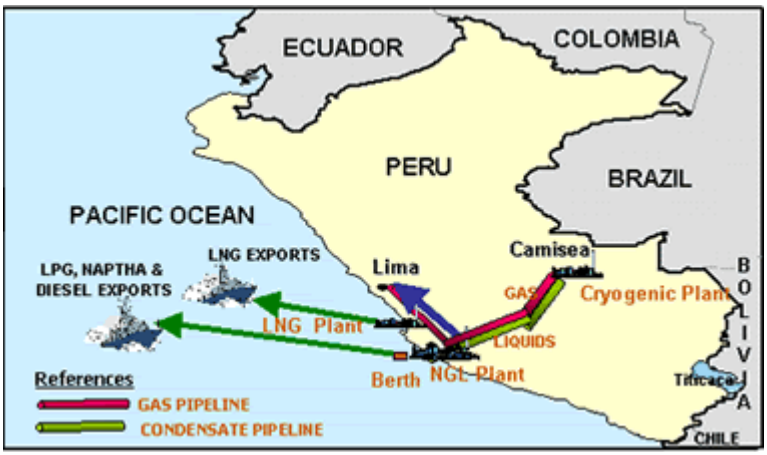
Map 1

Oleoducto Nor Peruano

Although PETROPERU does not operates oil fields, it operates the stations and the Bayóvar terminal that currently has a storing capacity of 2 million barrels of oil and the wharf is designed to dock ships of 1.5 million barrels.

The pipelines to transport the hydrocarbons from Camisea are operated by Transportadora de Gas del Perú (TGP). Its shareholders are Hunt oil, Sonatrach, Pluspetrol, SK Corporation, Suez-Tractebel and Graña and Montero (GMP). These pipelines, one to transport natural gas and the other to transport liquid hydrocarbons, run parallel (see **Map 2**). The first one has approximately 726 Km of longitude and transports 285 million cubic feet of natural gas from the Malvinas plant to the City Gate in Lurin. The second has an extension of 540 Km and carries 50,000 barrels of liquids of natural gas per day from Malvinas to the fractioning plant Melchorita in Pisco.

Map 2
Camisea Pipeline



As opposed to the Oleaducto Nor Peruano, the Camisea pipelines are operated completely by private firms. The main shareholders of the Camisea project have also interest on the pipelines, the fractioning plant (Pluspetrol) and the City Gate (TGP).

b. Processing

Peru counts with seven oil refineries that account for a total refining capacity of 210,200 barrels per day. **Table 8** shows that the state-owned company operates 4 refineries, thus controlling 42.68% of the total refining capacity. From these, the Talara refinery, the oldest in Peru (86 years old), has a capacity of 62,000 barrels per day and accounts for 29.5% of total domestic refining capacity. Petroperú has announced a project to modernize the refinery that will require an investment of US$ 1,000 million. The modernization will allow produce cleaner oil products. At present, Petroperú has contracted several consulting jobs to evaluate the project and it is expected that works will begin in June 2008.

The other three refineries that belong to Petroperú are much smaller. The refinery Iquitos, located outside this city, processes crude coming from the northern jungle. It produces gasoline, heavy nafta, turbo A-1, kerosene, diesel 2 and residual oil 6. All these products are sold in the cities of the jungle. The refinery Conchán is located 26.5 Km south Lima. It produces low octane gasoline, diesel, kerosene, residual oil and asphalt. The refinery El Milagro is located in the department of San Martín. It processes crude coming from the Station 7 of the North Peruvian Pipeline.

With regards to the refineries that are operated by private firms, the most important of all is La Pampilla. This is the largest refinery in the country and it is located in Ventanilla, nearby Lima and next to the Callao port. It is operated by the Spanish REPSOL – YPF. It has a refining capacity of 115,000 barrels per day, comprising 54.71% of the total refining capacity in Peru. It produces gasoline of 97, 95, 90 and 84 octane, liquefied petroleum gases, turbo A-1, kerosene, industrial petroleum and asphalts. La Pampilla processes mainly imported crude oil, because the technical characteristics of the Peruvian crude do not match the requirements of the refinery.

Table 8
Peru: Oil refineries and refining capacity

Contractor	Refinery	Refining capacity (barrels per day)	%
Petroperu	Talara	62,000	29.50
Petroperu	Conchán	15,500	7.37
Petroperú	Iquitos	10,500	5.00
Petroperú	El Milagro	1,700	0.81
Repsol – YPF	La Pampilla	115,000	54.71
Pluspetrol	Shivivacu	2,200	1.05
Maple	Pucallpa	3,300	1.57
TOTAL		**210,200**	**100.00**

Source: Ochoa and Távara (2007).

The refinery Shivayacu, located in Loreto, is owned by the Argentinean Pluspetrol. It refines the crude oil coming form the block 1-AB, property of the same company. It is the smallest of all the refineries in the country.

The refinery of Pucallpa, located in Pucallpa, is operated by the Canadian Maple Gas. It produces gasoline of 84 octane, kerosene, diesel and industrial petroleum. The refinery sells its products locally (Pucallpa and its surroundings).

The different refineries in Perú attend to segmented markets. The two largest refineries and Conchán attend the most dynamic markets (Lima and the other cities in the coast) while the smallest refineries attend the regional markets where they are located. In terms of vertical integration, both Petroperú and Repsol have distribution networks, as it will be seen in the next section.

c. Distribution and marketing

Before the privatization, Petroperu was a vertically integrated hydrocarbons company with operations in each of the value chain. The privatization design was aimed at promoting competition in the sector and, therefore, inhibiting integration.

One of the first measures of the privatization process was to sell the Compañía de Gas del Perú, a Petroperú's subsidiary in charge of the distribution of liquefied gas. In addition, a set of 83 gas stations were sold. This allowed the entrance to retail distribution companies such as Pecsa, Mobil, Shell and Repsol, which will compete with Petrored, an associated distributor to Petroperú. In the last years, there have been some acquisitions and the current retail distributors are Repsol, Petrored, Primax and Texaco.

With regards to the wholesale distributors, currently, there are 17 registered. At least seven of them, are engaged in other segments of the value chain such as refineries,

retailers and even crude oil contractors (i.e. Petroperú, Pecsa, Primax, Refinería La Pampilla, Repsol, Maple Gas and Mobil Oil).

5. EXPLORATION

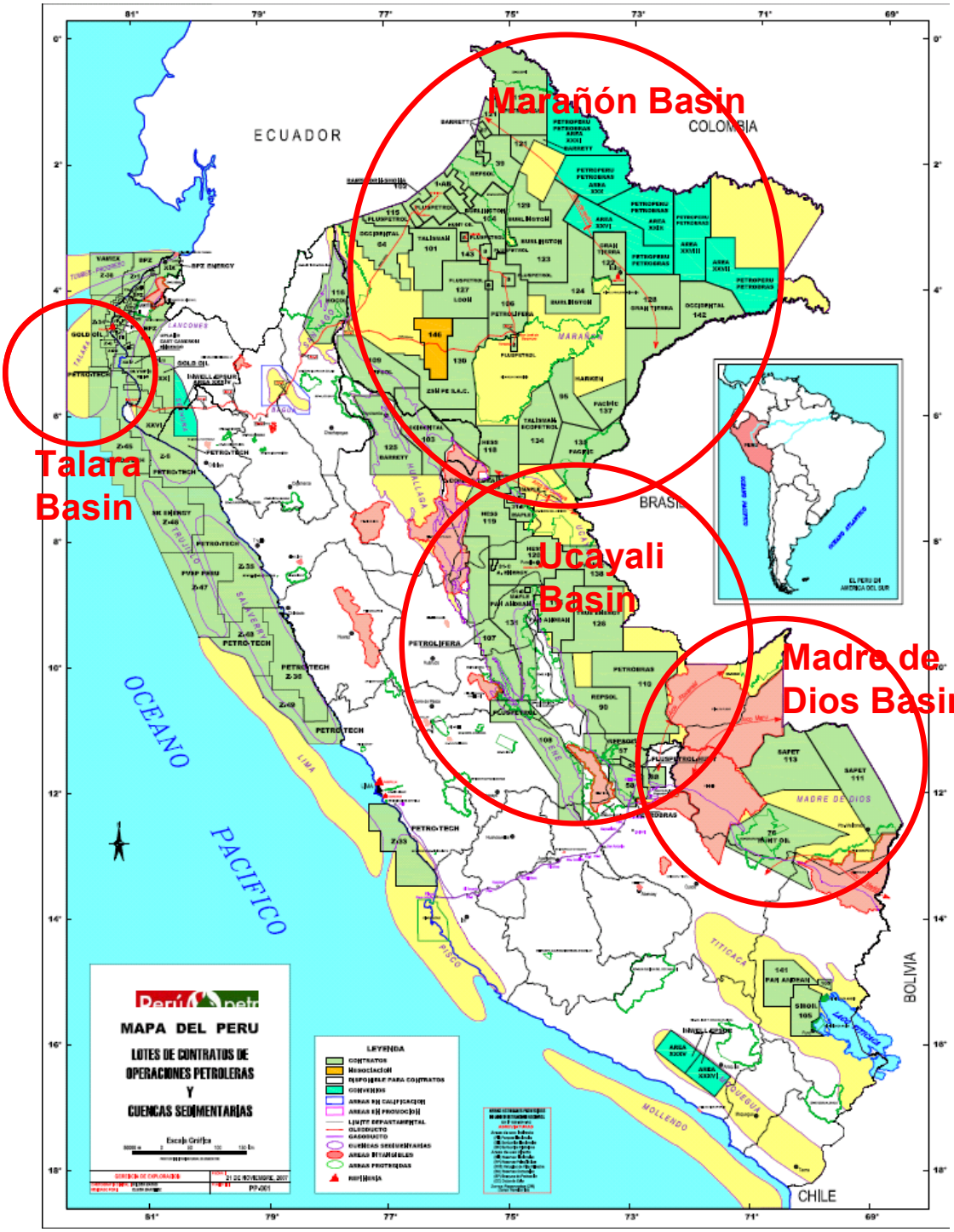
During the first years after the change in legislation, despite the favorable conditions for investment there have not been major hydrocarbons' discoveries. In fact, reserve figures remained stagnated till the mid 1990s. During the last decade, there has been a sustained increase in probable reserves while proved reserves had a meager increase.

Table 9
2006: Exploration contracts

Contractor	No. of Exploration blocks
Occidental Petrolera / Amerada Hess / Talisman	2
Repsol / Burlington	3
Maple Production	1
BPZ Energy	2
Petro-Tech	4
Consultora de Petróleo	1
Occidental Petrolera	1
Harken	1
Burlington	3
Petrobras Energía	3
Petrolífera Petroleum	2
Sapet	2
Pluspetrol	2
Ramshorn / Shona Energy / Andean Oil and Gas	1
Siboil	1
Repsol	1
Hunt Oil	1
Amerada Hess	3
Gold Oil	1
Petrobras Energía Perú S.A.	1
Barrett	2
Pan Andean, Consultora de Petróleo	1
Gran Tierra	2
Hocol	1
Total	**42**

However, in the last two years some major discoveries have been done. These include the discoveries in Blocks 67 and 39 in the northern jungle. In Block 39, PERUPETRO estimates that Repsol will be able to peoduce 100,000 barrels daily. In Block 67, Barrett Resources announced that estimated resources amount 300 million barrels of oil and will produce 100,000 barrels per day. Other important discoveries are the ones found in Blocks Z-1 and Z-2B in the Talara basin, which amount for a potential production of 50 million of cubic feet per day. In addition, there have been two important discoveries of natural gas. Pluspetrol found 3 trillion cubic feet of gas in Block 56 and a consortium among Repsol and Petrobras found 2 trillion cubic feet in the adjacent Block 56.

Map 3
Peruvian Hydrocarbon Basins



Geology and discoveries

Peru has always been considered as an unexplored but rich country in hydrocarbons resources. In fact, it was considered that its geological configuration was similar to those other oil and gas producing countries in South America, thus the meager results in

production were attributed to unfavourable investment conditions and to a lack of exploration activities.

The most important hydrocarbons basins in Peru are the Talara Basin, located in the northwestern part of Peru; the Marañon Basin, located in the northern jungle; the Ucayali Basin in the central jungle and the Madre de Dios Basin in the southern jungle. Recent discoveries seem to be confirming Peru's considerable potential in oil and gas resources.

The Talara Basin

This is the first oil basin discovered in Peru. The first oil discovery dates back 1869. It is estimated that "more than 1.68 billion barrels of oil (BBO) and 340 billion cubic feet of gas (BCFG) have been produced… in the Talara Basin province" (Higley, 2004). This basin concentrates oil and minor gas fields in the onshore. It also has a huge potential for gas resources, but require the construction of adequate infrastructure (i.e. pipelines). Estimated recoverable resources from undiscovered fields in the basin are 1.71 BBO and 4.79 trillion cubic feet of gas and 255 million barrels of natural gas liquids (Higley, 2004).

Oil in this basin tends to be heavy, between 20 and 35 API gravity. For this reason, they are exported and not treated in the Talara refinery.

In the last two years, there have been two major discoveries in this basin. In March 2007, Petrotech has discovered gas in the Block Z-2B. It is expected that potential output would reach 15 million cubic feet per day (Andina, 2007b). Petrotech has been exploiting around 3,500 barrels per day of light crude oil in the East San Pedro 1X field in this same block. Required investment to develop this field will reach US$ 100 million.

In November 2007, BPZ announced a discovery of heavy crude oil (API 22) in offshore wells Corvina CX11-21XD and Corvina CX11-14D. Estimated reserves are around 400 million cubic feet of natural gas and it is expected that output will be around 3,150 barrels per day. This area has been explored before by Belco and Petroperú but studies indicated the existence of dry natural gas, which was not economically profitable in the 1980s (El Comercio, 2007a and b). It is important to mention that BPZ would invest US$ 200 to build a thermal generation plant of 160 MW and to continue the exploration.

The Marañon Basin

The Marañon Basin is located in the eastern slope of the Andes and the Amazon region. The cumulated production of this Basin is around 827 million barrels of oil. This Basin has good prospects in heavy crude oil.

In late 2006, Barrett Resources has declared economically feasible the reserves of heavy crude oil in Block 67 in Loreto nearby the Ecuadorian border. The estimated production of this field could reach 100,000 barrels per day by year 2010. Current oil prices make attractive the development of this project that will comprise the drilling of 5 wells and the construction of a 400 Km. pipeline to carry the oil to the coast (to the Station 5 of the Oleoducto Nor Peruano).

The General Hydrocarbons Director declared that the construction of the pipeline would take advantage of the reserves found by Repsol a year before. Repsol found in Block 39 heavy crude oil (API 15). It is expected that the field will produce 21,000 barrels per day by

late 2011. The estimated investment to develop this field is US$ 531 million. (La República, 2008).

The Ucayali Basin

The Ucayali Basin is located south the Marañon Basin and north the Madre de Dios one. This is a relatively unexplored area but it is attracting a lot of attention since the discovery of the natural gas Camisea deposit. Additional estimated reserves are around 17 billions of barrels of oil equivalent.

The major discovery in this basin has been the Camisea deposit found by Shell in 1984. This company did not reach an agreement with the Peruvian government and later the Argentinean Pluspetrol signed a license contract to develop and exploit the deposit. This deposit (Block 88) has proven reserves of 10.4 trillion cubic feet. In addition, Pluspetrol has found reserves of 3 trillion cubic feet in the Pagoreni deposit (Block 56) next to Camisea. Both Camisea and Pagoreni are part of the Camisea project that entered into operation in 2004.

Early this year, the Spanish Repsol YPF in a consortium with the Brazilian Petrobras and the American Burlington Resources, announced the discovery of 2 trillion cubic feet of natural gas in Block 57 (next to Pagoreni and Camisea). This discovery raises the need to build another pipeline, because the one built for the Camisea project is exclusive to transport the natural gas coming from Blocks 88 and 56 (El Comercio, 2008).

The Madre de Dios Basin

The Madre de Dios Basin lies on the Amazonian side of the Andes. It shares geological similarities with the Ucayali Basin.

The discovery of the Candamo deposit (Block 78), 350 Km southwest Camisea, has estimated reserves of 3 trillion cubic feet of natural gas and 120 million of barrels of condensates. Mobil Oil explored Block 78 between 1996 and 1999, but had to abandon it because the deposit lies in one of the most reckoned national park and there was an intense international campaign that opposed to the project. After Mobil left, the surface area was included in the Bahuaja-Sonene National Park, a conservation areas where productive activities are forbidden. Last year, there have been some efforts to cut this national park and offer the Block back to exploration but again public opinion was against this initiative (La República, 2007b).

Situations like the described above will have to be discussed and considered in the design of an adequate policy of exploitation of natural resources. It is necessary that the hydrocarbons the conservancy policies get well-matched, otherwise investors will not be willing to take the risk in this basin that is rich in biodiversity.

Prices and its impact on exploration in Peru

Oil prices have increased steadily over the last 5 years, for example, spot prices for West Texas Intermediate went up from US$ 20.26 in 2002 to US$ 60.81 in 2007. Moreover, during 2008 prices have broken the US$ 100 barrier. Analysts, such as Fattouh (2006) and Williams (2007), report that the decrease in spare capacity of OPEC countries is one of the main reasons for this boost in prices. Till the past decade, Saudi Arabia had a

considerable spare capacity that entered into production to address an increase in demand. Since 2004, spare capacity is calculated at only 2 million barrels per day, around 2% of global oil demand which has proved to be insufficient to adjust the international market (Fattouh, 2006).

The consequences of this shortage, in a context of an accelerated global demand and slow supply growth in non-OPEC producers is causing accelerated rise in oil prices and increasing its volatility. Perspectives of reversing this shortage situation are limited, since crude oil production has not grown in the last 2.5 years and supply increase in hydrocarbons has come from natural gas liquids. This increase supply cannot meet the current growing demand for gasoline, diesel or jet fuel (Rubin, 2008).

This context of increasing prices is making Peruvian oil basins more attractive to international investors. The unattractiveness of heavy crude oil is being offset by high prices. In fact, Rubin and Buchanan (2008) forecast oil prices will reach US$ 150 per barrel in 2010 and will hit US$ 200 by 2012.

With these prices, the investment decision will favour heavy crude oil projects. In fact, 24 new exploration contracts were signed last year, a record by Peruvian standards. Together with this increased interest in the private investors, PETROPERU is also devoting more efforts to raise capital to increase and improve its infrastructure. For example, it is accelerating the bid process to modernize the Talara refinery. The project will require an investment of around US$ 1 billion and 18 firms have stated their interest in the project. The modernization of the Talara refinery will allow produce higher value added products, as well as attend the increasing refining demand of the crude oil wells in the northern jungle. In addition, plans for modernizing the Talara terminal and construction another pipeline in the Oleoducto Nor Peruano are aimed at transforming Talara in an oil hub to export oil products to Asia.

6. TECHNOLOGICAL CHANGES IN THE HYDROCARBONS INDUSTRY

Impacts of technological change in the industry

The hydrocarbons industry is a mature industry, with more than a hundred years of development. During all this period, the industry has changed dramatically in terms of gains of efficiency. Chandler (1990) has reported that cost advantages of scale critically shaped the growth of firms and determined the structure of the industry. To exploit these economies of scale oil companies had to make three interrelated investments in production, marketing and management.

Concentrating in production investments, critical innovations made possible to take advantage of economies of scale. In the early period of consolidation of the oil industry, critical innovations were related to the refining stage rather than the extraction one. By 1870, increases in the optimum size of refineries (i.e. from 500 hundred barrels per day to more than 1,000 barrels) allowed to reduce unit costs to almost one half. The increase in throughput demanded more efficient ways to transport refine and they were achieved by changing railway transportation to pipelines. By 1920, increased competition in the industry was faced through increased innovation to achieve more continuous production processes and to produce higher-octane gasoline such as continuous distillation, thermal-cracking process, tube and tank process and fluid continuous catalytic process (Chandler, 1990).

In more recent times, with signs of scarcity and the 1970s energy crisis, radical technological innovations have been related to increase the efficiency of exploration and development (E&D). "Technological advances such as three-dimensional seismic techniques, polycrystalline diamond compact drill bits, horizontal drilling, and offshore platforms capable of operating hostile, deep-water environments are widely-acknowledge to have had significant impact on productivity in E&D" (Caddington and Moss, 1998, page 2).

Based on technological diffusions in the petroleum industry between 1947 and 1990, Caddington and Moss (1988) found that around 10% of total diffusions were related to new computer technologies or the application of computer technology to existing techniques or equipment, especially in the areas of seismology and reservoir rock and fluid systems evaluation and drilling. Computers have made possible to process and transmit large amount of data from remote locations to central offices as well as simulate the behavior of fluids in reservoirs.

About 20% of diffusions consisted of technologies for evaluating hydrocarbon-bearing rock formations, such as well logging and testing. Most of these technologies occurred in the 1950s and 1960s, but since then incremental innovations have taken place. Another 20% were associated to the exploration and development of offshore resources, especially improvements in fixed and non-fixed offshore structures and floating drill systems. Finally, about one third of diffusions were related to drilling, such as the development of more durable bit bearings and tungsten carbide inserts; polycrystalline diamond compact drillbits; and automated rigs and rig power systems (Cuddington and Moss, 1988).

The natural gas industry would have not been possible without the development of the liquefaction of gases technology (LNG). The liquefaction process involves the condensation of gas into a liquid at close atmospheric pressure by cooling it at -163°C. The reduction in volume makes it cost-efficient to transport gas over long distances by cryogenic vessels.

Another important innovation has been the conversion of natural gas into synthetic fuels (Gas to Liquid Technology – GTL). This process tears natural gas molecules apart and reassembles them into longer chain molecules, like those that comprise crude oil. The result is pure synthetic oil free of contaminants (Genovese, Gorlani and Arroyo, 2005). This technology is scalable, thus allowing construct smaller plants. However, large oil firms are targeting at the development of large-scale plants (Bontempo, Almeida and Bicalho, 2005).

Adoption of technological change in Peru

Since the economic reforms and the incentives for private investment were launched in the 1990s, Peru has experienced the modernization of most part of its productive sector. Foreign investment in the hydrocarbons sector has brought modern technologies that are currently of standard use in the industry such as 3-D seismic, the development of slant-type wells, the use of simulation and testing models to evaluate wellbore stability and fluid analysis, among others.

All these technologies are being deployed in the exploration and development of oil and gas blocks around the world. Engineering companies responsible for the design and construction of facilities contribute to diffuse these state-of-the-art technologies. On the other hand, the Peruvian government through environmental legislation set standards that

have to be met, for example to minimize environmental impact in areas with rich biodiversity.

However, there is little endogenous technological capacity in Peru. Domestic engineering companies might be aware of technological advances and could be deploying them, but they hardly have the capacity to innovate or the opportunity since challenging contracts are usually granted to international and well-known companies under engineering, procuring, construction and management (EPCM) contracts. On the research side, universities and technological institutions have little funding to pursue any research or development projects in the hydrocarbons sector. In addition, hydrocarbons are not included as priority sectors in the Peruvian National Plan of Science, Technology and Innovativeness.

7. GAS VS. OIL IN PERU

The discovery of natural gas deposits dates back to 1961, when Mobil Oil discovered the Aguaytía deposit in the department of Ucayali, 77 Km. the city of Pucallpa. The project was never developed because it required the construction of a pipeline to transport the gas to the coast.

Some years later, between 1983 and 1987, the development of the Camisea deposit meant a major opportunity for Peru to participate in the dynamic market of natural gas and to change the pattern of energy consumption and production in the country. Despite the magnitude of the deposit, the Peruvian government did not reach an agreement with Shell for the exploration and exploration of the deposit.

Fortunately, after the economic reforms of the 1990s and the change in the hydrocarbons and investment legislation both natural gas projects were developed. In 1993, the Maple Gas won a 30-year concession to develop and commercialize the Aguaytía gas. The project also comprised the construction of a generation plant of 155 MW in Aguaytía and the set up of transmission lines to the Paramonga Electric Station, in the coast.

In 2000, a consortium led by Pluspetrol won a 40-year concession to develop and commercialize the Camisea gas. In addition, another concession was granted to Tecgas to transport the natural gas and liquids to the coast of Peru, as well as to commercialize and distribute the natural gas in Lima.

At present, both projects are in operation and have changed dramatically the hydrocarbons scenario in Peru. From a country with limited crude oil resources that did not attract the attention of private investors, Peru is changing into a country with considerable undeveloped and undiscovered hydrocarbons resources. In addition, even with the recent developments in international markets, Peru is showing economic stability and limited political risk.

Economic impact of Camisea

The Camisea deposit is located in the jungle of the department of Cusco. Pluspetrol has been granted a 40-year concession to develop and commercialize the natural gas and associated liquids. The Camisea project comprises the extraction, commercializing, transportation and distribution of natural gas in Lima. Proven reserves in Block 88 stand at 10.4 trillion cubic feet.

A second stage of the Camisea project involves the construction of a liquids of natural gas (LNG) plant in Pampa Melchorita in Ica. Hunt Oil, SK Corporation and Repsol expect to have the GTL facility operating by 2009. Expected output is around 4 million metric ton per annum (MMTPA) for delivery to the West Coast of North America. Block 56[7], conceded also to Pluspetrol, will supply natural for the LNG plant. Proven reserves in Block 56 stand at 3 trillion cubic feet.

The economic impact of the Camisea project is enormous. First, it is reducing energy costs in Peru. It is estimated that energy savings will be around US$ 4,100 millions in a period of 30 years (net present value). These savings include the reduction of 30% in the marginal costs of generating energy, the substitution of expensive fuels like diesel and industrial petroleum in energy intensive sectors such as cement and steel, and the conversion of gasoline automobile engines to gas. Second, it is expected that the project will add around 0.8% to the GDP during the years of concession, as well as will contribute to the increase in tax revenues and in national income through the payment of royalties. Finally, associated to the substitution of fuels there will be an improvement in the quality of air in Lima (TGP, 2007).

Changes in energy consumption patterns

One of the main impacts of the Camisea project in the Peruvian economic structure is the one related to the change in the pattern of commercial energy use. As it is shown in **Table 10**, energy use in Peru is mainly based on petroleum, but in less than 2 years the participation of natural gas in the generation of commercial energy has increased from 6.4% in 2003 to 21.7% in 2005.

Table 10
Peru's energy consumption pattern: 2003 -2005

Source of energy	Use pattern (%)	
	2003	2005
Carbon	4.6	4.8
Oil	69.4	60.1
Hidroenergy	19.6	13.4
Natural gas & LNG	6.4	21.7

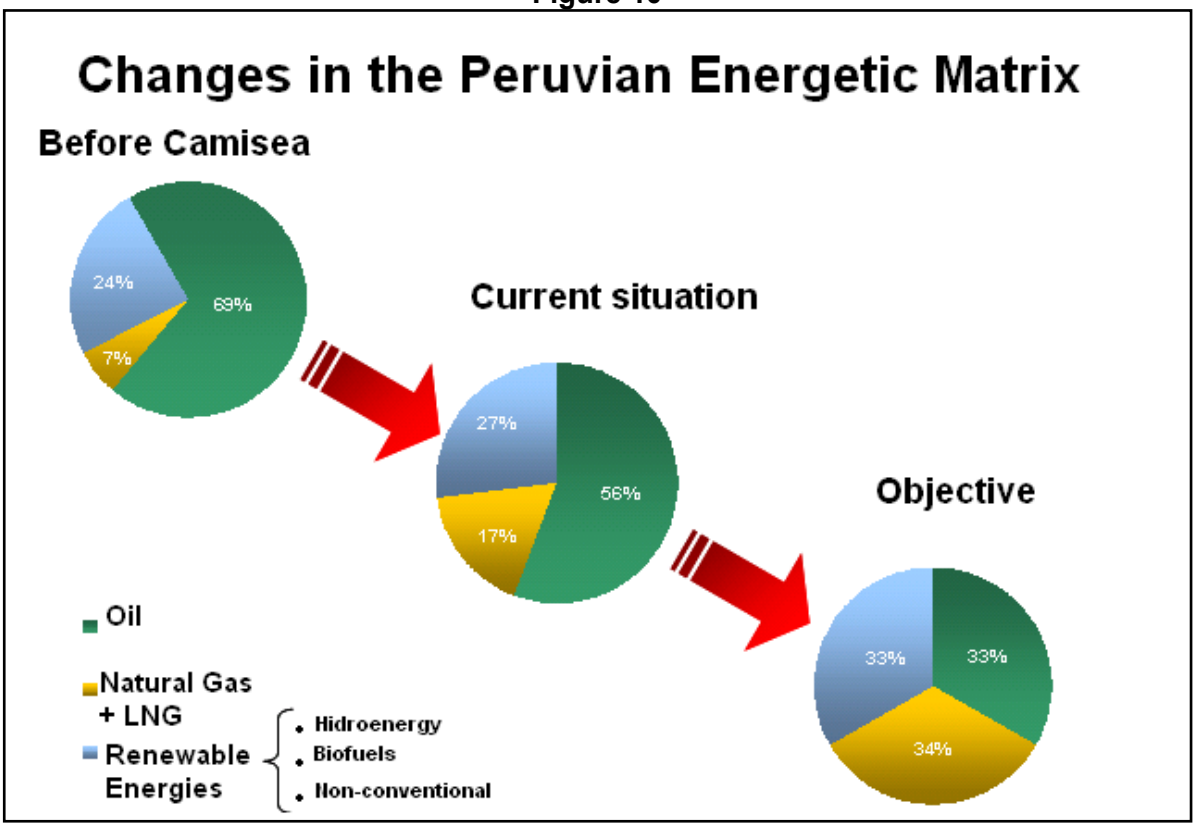
The latter change is part of a strategy launched by the Ministry of Energy and Mines to change the energetic matrix by consuming abundant energy sources like gas and promoting the development and use of renewable sources of energy, such as hydroenergy, geotermic, solar and eolic energies, as well as biofuels (see **Figure 10**).

Three specific measures were taken to attain the latter objective. First, a fixed price was set for the gas price to be used in the generation of electricity. According to the estimates made in 2002, this price was US$ 1.92 per million BTU against US$ 3.15 for other uses. Second, ELECTROPERU signed a contract to buy 70 million cubic feet per day in take or pay contract for 80% of that amount of gas. Finally, to guarantee the transportation of gas,

[7] Block 56 is next to Block 88 and has also been conceded to Pluspetrol. However, the contract with the Peruvian government establishes that the natural gas from Block 88 will be devoted to satisfy the domestic market.

electric energy consumers would pay a contribution in their bills as a compensation for lower electric energy fees.

Figure 10



Fuente: Navarro (2007).

The results of these measures are that in 2007 around 20% of the electricity is generated using natural gas. There are 5 electric generation plants using natural gas: Santa Rosa, Ventanilla and Chilca in Lima; Malacas in Talara; and Aguaytía in Ucayali. But the final goal is to increase gas consumption by 34% in year 2011.

Another crucial measure is to promote direct household consumption. The latter point is presenting some delays because municipalities in Lima are charging households for connection charges in addition to those charged by Calidda, the firm responsible for the distribution. This impasse is delaying the delivery of gas in Lima and discouraging households to change to this energetic alternative.

Meanwhile, the Hydrocarbons Directorate (DGH) has received the proposal to construct a gas pipeline to carry gas from Camisea to the departments of Cusco, Arequipa, Moquegua and Puno[8]. This project would not only increase domestic and industrial gas consumption but would also have a decentralizing effect.

[8] Another option to deliver gas to the southern part of the country was proposed by Suez gas company. The latter would carry gas from Ica (Pampa Melchorita) to Moquegua and Ilo. However, as both proposals would be redundant the government opted for the one that would deliver gas to the departments adjacent to Camisea, in response to pressures from the regional governments and the rejection of a wide sector of public opinion to the possibility of exporting gas to Chile.

On the other hand, the Urban Transportation Directorate of Lima has taken two measures to promote the substitution of diesel to gas. On the one hand, it has launched a plan to replace cars that consume diesel by granting a US$ 2,500 bonus to all drivers that will change their old cars for new ones that consume gas. This proposal is waiting for the Congress approval to procure around US$ 50 million a year to attend the replacement of vehicles. On the other hand, this municipal entity has constructed the biggest gas station in Latin America. The station has the capacity to fill the tanks of 32 cars simultaneously.

From net importing to net exporting country

Camisea has opened the opportunity to revert the Peruvian situation from a net importing to a net exporting country of hydrocarbons. The recent increase of Camisea's proven reserves in 23% will allow export gas to Mexico. According to the contract signed between Pluspetrol and the Peruvian government, gas coming from Block 88 will only be used to satisfy domestic demand but resources coming from Block 56 will feed the Pampa Melchorita LNG plant and will be exported to the Mexican market.

One of the challenges to become a net hydrocarbons exporter is to build adequate infrastructure to transport the new oil and gas resources that have recently been found. In that regard, the construction of extensions to the Oleaducto Nor Peruano and the modernization of the Talara refinery are crucial, as well as the construction of a new pipe to transport the gas found in Block 57.

Another one is to increase the domestic refining capacity, even though that would mean to import light crude. The fact is that domestic production of certain kind of fuels such as high octane gasoline and turbo fuels would reverse the trade balance deficit because of the high price of these fuels compared to the price of crude oil.

Besides the required investments mentioned before, the exploration rhythm must continue because that is the only guarantee to increase hydrocarbons output. In that regards, the Peruvian hydrocarbons sector should built a geological map such as the one built for mining resources and develop detailed information databases for the use of potential investors.

Finally, a policy issue that is beginning to emerge with regards to the Camisea gas is whether the gas should be exported without any transformation. The signed contract between Repsol and the Peruvian government supports the first policy option. It is established that 500,000 millions of cubic feet per day will be exported during 15 years to Mexico. The earnings estimates are around US$ 15 billion. However, some experts are questioning if this is the most appropriate option since earnings could be seven times higher if the gas is exported in the form of petrochemicals (La República, 2007b).

8. CONCLUSIONS

This paper has reviewed some of the major highlights of the Peruvian hydrocarbons industry. The sector has experienced a major change in the last decade and, in the recent years, the results are becoming evident. However, there is still much to do in terms of fine-tuning regulatory policy and to secure adequate transparency that provide major stakeholders the trust the benefits of this industry are adequately distributed.

The change of the legislative framework to promote private investment has been one of the cornerstones in the expansion and modernization of this sector. From a state-owned monopoly dependent to the dictates of the central government priorities, the industry has

evolved into a one where several firms participate, both in upstream and downstream activities, and receiving high levels of investment. However, major challenges are still to be faced.

In the regulatory area, the increase of oil prices has changed completely the market context. Peruvian legislation established royalties at a maximum rate of 20% of fiscalised production. However, the experience is that companies are willing to pay more than that amount. It is required to review all the contracts and evaluate a way to increase government take on a long-term basis without affecting the trust of investors. The government is willing to maintain the status quo and pressures to change negotiation conditions are not strong since regional governments are receiving increasing financial resources.

Another area that requires review is that concerned with the transparency of downstream contracts. The fact that hydrocarbons belong to the contractor that extracted them, poses certain questions about the distributions of rents in a context of rising prices. Contracts among private parts are private but the government has the responsibility to secure transparency. The allegation about the extraordinary future earnings in the gas exports to Mexico require an adequate follow up.

Related to the latter the competition regime in the industry needs to be better regulated. Investment consortia with the same partners or associated firms need to be analysed because they overcome the regulatory framework. In addition, INDECOPI needs to be strengthened to fulfill its mandate.

With regards to the areas that secure the performance of the industry, exploration must receive major attention. The latest findings show that Peru has a great hydrocarbon potential and the amount of signed contracts in the last year indicate that investors are beginning to see Peru as an attractive place; however, it is necessary to provide more information about the geological characteristics of the oil basins. Peru is an under-explored hydrocarbons region and government institutions should organize and release geological information in the form of a hydrocarbons geological map. This effort should also be coupled with those devoted to strengthen the technological capabilities of domestic firms. This is necessary to build up related services to this industry and create clusters or linkages with other productive sectors. Furthermore, universities should not be put aside from these efforts since they can create knowledge and can provide technical solutions to specific problems found in the Peruvian oil basins or related to the characteristics of the heavy crude oils produced in the country.

The Camisea gas is contributing greatly to change the configuration of the Peruvian hydrocarbons industry. Besides providing with important resources to revert in the medium and long run the shortage in hydrocarbons, it is contributing to change the domestic matrix of energy consumption. Some changes are evident, such as the increase of electric energy generated by thermo-electric plants feed by gas; however, the major challenge remains the increase of direct domestic consumption. Efforts to speed up the setting of the domestic connections must be devoted, thus bottle necks between local municipalities and the firm that is currently assuming all the costs of the connections should be solved.

On the other hand, the greatest impact of Camisea, and of other gas findings, is the possibility of becoming a net hydrocarbons exporting country. The possibility of gas exports to Mexico is almost a reality, but again there are regulatory and policy issues that demand attention of the Peruvian government. On the regulatory side, the question is how the government can secure an adequate share of the rent without jeopardizing the judiciary stability and promote transparency. On the policy side, the government must design a policy strategy with respect to become a gas exporter or to promote the development of a

petrochemical industry. The positive perspectives in this industry require this decision making because recent experience has shown that the market forces are not enough to deal with long-term issues.

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