Metrology for the Natural Gas Sector - Trilateral Cooperation with Latin America

Johannes Emmerling

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-abridged version-

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ABC	Agência Brasileira de Cooperação
AGA	American Gas Association
API	American Petroleum Institute
BMZ	(German) Federal Ministry of Economic Cooperation and Development
CENAM	Centro Nacional de Metrología
CESI	Catalytica Energy Systems
CIDI	Consejo Interamericano para el Desarrollo Integral.
CNG	Compressed Natural Gas
CTGAS	Centro de Tecnologias do Gás
FEMCIDI	Fondo Especial Multilateral del CIDI (OAS)
GTZ	German Technical Cooperation
IADB	Inter-American Development Bank
IBMETRO	Instituto Boliviano de Metrología
INDECOPI	Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual
INMETRO	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial
IPT	Instituto de Pesquisas Tecnológicas, Sao Paolo
LNG	Liquified Natural Gas
MDG	Millennium Development Goals
MSTQ	Metrology, Standardization, Testing, and Quality Assurance
NIST	National Institute of Standards and Technology
NMI	National Metrology Institute
NMi	Nederlands Meetinstituut
OAS	Organization of American States
ODA	Official Development Assistance
OSINERG	Organismo Supervisor de la Inversión de Energía

PTB	Physikalisch Technische Bundesanstalt
SEDI	Secretaría Ejecutiva para el Desarrollo Integral
SIM	Sistema Interamericano de Metrología
SRE	Secretaría de Relaciones Exteriores (Mexico)
SRI	Southwest Research Institute
YPFB	Yacimientos Petrolíferos Fiscales Bolivianos

Conversion factors

1 cubic meter (m^3) = 35.315 cubic feet (cft)

1 m^3 of natural gas ≈ 37-41 mega joules (MJ) ≈ 10.3-11.4 kWh ≈ 35-39 thousands Btu

1 ton oil equivalent (TOE) ≈ 1.42 ton coal equivalent ≈ 1020-1130 m^3 of natural gas

1 ton of liquefied natural gas (t LNG) ≈ 1350 m^3 of gas

1 Background and aim of the study

This study aims to contribute to the development of future cooperation opportunities in the energy sector and specifically the role metrology and the entire quality infrastructure in Latin America. It identifies the core problems, its significance to the continent, analyzes the specific requirements to come up with suitable contributions and fields and actors that should be integrated in a potential project in this area.

The recent changes of traditional bilateral development cooperation to more comprehensive and coordinated approaches particularly with emerging countries like Brazil or Mexico (sometimes referred to as “anchor-countries”) provide the conceptual background. While the emergence of innovative poles in these countries provides valuable resources also for donor institutions, the political, institutional and technical circumstances are to be explores in detail to develop successful projects. Thus, opportunities of trilateral cooperation or horizontal cooperation are explored.

This study focuses on metrology for utilities and takes the natural gas sector as premier example. The focus on gas is indebted to the increasing role it plays for the energy supply but also the recent developments in Latin America regarding the international trade, which is becoming more important.

Regarding the institutions involved, two major actors in the field of cooperation on metrology were taken into account: the Organization of American States (OAS), which is the major political representative bodies of the Americas based in Washington D.C., and the International Technical Cooperation of PTB ("Physikalisch Technische Bundesanstalt" - German National Metrology Institute), which is also a major actor providing assistance in development cooperation in this field. Additionally, other actors as the Inter-American Development Bank (IADB), the World Bank, and the U.S. National Metrology Institute NIST (National Institute of Standards and Technology) have been included.

The specific field of trilateral cooperation in the sector of metrology for the natural gas sector has been identified as a potential area of cooperation by officials from both the PTB and the OAS in May 2006. This pre-feasibility study hence looks at the political, institutional and technical background and requirements in order to provide recommendations and options for the cooperation on this topic.

It is based on communications with the OAS, PTB and other donor institutions. Additionally, the general and specific literature has been reviewed including the relevant institutions’ publications and strategies. Furthermore, four countries that have been preliminary identified as possible cooperation partners have been visited to understand the specific capabilities, needs and requirements of the local institutions. Brazil and Mexico were selected as contributing countries while Bolivia and Peru were chosen as potential recipient countries. The decision to include these four countries was based one their capabilities and requirements in gas metrology and the relevance of natural gas for their respective economies. Semi-structured interviews have been conducted with officials from relevant ministries, metrology institutes, laboratories and companies in these countries. A list of all persons interviewed can be found in the appendix.

This report first gives an overview on technical cooperation on metrology. Subsequently, it looks on the specific topic of trilateral and horizontal cooperation and its role for the donor institutions. Then, the natural gas sector in Latin America is explored including the requirements for metrology in this sector. The specific situations in the four countries mentioned before are analyzed in chapter five mainly based on the interviews conducted. Thereupon, in chapter six I draw up specific recommendations for potential cooperation opportunities in this area.

2 Technical Cooperation on Metrology in Latin America

Technical cooperation builds economic, organizational and technical knowledge and skills. It is intended to strengthen the performance capacity of individuals and organizations, and thus support above all the poorer sections of the population. In the field of quality infrastructure, aims at the areas of Standardization, Metrology, Testing, Certification and Accreditation. The term „quality infrastructure“ covers all institutions active in these fields, ranging from National Metrology Institutes (NMIs) to laboratories, accreditation bodies and others. Even though these institutions area might appear invisible to people, they have important impacts on society. They include the legal aspects and national conditions (governance), the impact on the production of goods, international trade and the final consumers.

For the private sector, the improvement of its competitiveness and its integration into the global trade system are the major goals. For the public sector, it is important to establish transparent institutions that provide an enabling environment. Ultimately, consumers will benefit through improved quality of products and services they buy based on quality and quantity measurements they can rely on. While the target group of specific measures in the technical cooperation on quality infrastructure is regularly a particular sector, its benefits accrue to society at large.

Programs and Strategies of relevant donor institutions

In Latin America, there have been great efforts undertaken during the last decades to support the development of the quality infrastructure. They included the establishment of National Metrology Institutes, in countries like Brazil or Mexico up to the international accreditation. Moreover, laboratories, accreditation bodies, bureaus of standardization and legal entities have been supported. On the international level, the cooperation both within the American Continent and with other regions has been fostered.

Particularly, German PTB possesses over forty years of experience of technical cooperation on this continent. Its major goal is to create quality infrastructure for the economy and the consumers. It thus aims at contributing to fighting poverty, sustainable management of natural resources and the modernization of state and society. PTB's contribution mainly consists in consulting, training and awareness raising among officials, and the organization of workshops and events. On the international level, PTB also supports the organization of comparison programs and other measures to establish the principles of traceability and comparability.

Regarding the programs for the different countries, PTB adapts is projects to the different situation in the sector of metrology. Specifically, the more advanced institutions like the National Metrology Institutes (NMIs) in Brasil (INMETRO), Argentina (INTI) and Mexico (CENAM) are started providing assistance to other countries since they already achieved a comparable high level including international acceptances.

The Federal Ministry for Economic Cooperation and Development of Germany (BMZ) names the three main areas for the cooperation with Latin America: fight against poverty, the protection of the environment and the natural resources, and the modernization of state and society. The PTB aims at contributing to efforts in these areas.[1] As of today, PTB has projects in seven countries in Latin America totaling a 12.3 million Euros of contributions and four regional projects worth 2.85 million Euros.

The Organisation of American States (OAS) is working on the issues of quality infrastructure through its Department of Science and Technology. Its knowledge of national, regional and international institutions engaged in science and technology activities, its recognized experience in technical cooperation with the countries of the region, and the subject areas of its expertise, are key tools that put the department in a position of comparative advantage for fulfilling the mandates and recommendations received by the OAS in this field.[2] Being the major political body comprising all countries of the hemisphere, it mainly supports the regional bodies that have been installed to support the regional cooperation in this field. Namely, it stands behind the institutions in the area of metrology (support to the Sistéma Interamericano de Metrología SIM), standards (Pan American Commission on Technical Standards COPANT) and

[1] See PTB (2004) for more details on the PTB's strategy.

[2] OAS (2001, p.1)

accreditation (Inter-American Cooperation on Accreditation IAAC). To spur the development of technical infrastructure for evaluation of the goods and services traded among member states and hence to facilitate the harmonization of a metrology system is its aim.

Other multilateral organisations such as the World Bank and the Inter-American Development Bank have been working additionally on specific topics in the area of quality infrastructure. Alongside, other bilateral donors have programs that integrate supporting measures to specific organisations in Latin America even though to a lesser extent.

Other NMIs such as the National Institute of Standardisation and Technology (NIST) of the USA are also providing technical assistance. These institutes are regularly active in scientific-technical co-operation with their counterpart NMIs in other countries. Thus, the contributions are more on the scientific and technical level that benefits all the participating institutions (e.g. through the exchange of staff, organization of workshops, training courses, etc.). This does regularly not involve dedicated funds for development cooperation. Instead it is financed through the regular budget of the respective NMIs. In contrast, cooperation financed by development cooperation funds is based on a separate mandate. For instance, the NIST can only make greater contributions when financed e.g., through external funds like from USAID; only slight contributions could be operated through the regular budget. German PTB therefore exhibits a unique position as it can be act regularly as a part of German development cooperation spending official development assistance (ODA) funds. Nevertheless, the expertise and know how of other NMIs can and should be integrated on the level of scientific-technical cooperation.

3 Trilateral Cooperation

In the field of development cooperation, the importance of mutual cooperation amongst the developing countries has gained ground in the last decades. The ‘traditional’ bilateral development assistance was found to put too little attention on the regional setting of a country. Moreover, the effectiveness of the North-South cooperation appeared to be somewhat weak besides the frequent changes of the development policy agenda. As a result, concepts named South-South, South-South-North, triangular, tripartite or trilateral cooperation were debated and put into practice.

While the idea of South-South cooperation dates back already to the 1950ies (e.g., the Bandung Conference 1955), its relevance for the national and international actors took of only some decades later. In 1972, the General Assembly of the UN established a Working Group on Technical Cooperation among Developing Countries (TCDC) that established ways of how to best implement such policies. Based on the work of this working group, the UN General Assembly put in a resolution, that it "urges developing countries and their partners to intensify South-South and triangular cooperation in these areas, as they contribute to the achievement of the internationally agreed development goals, including those contained in the United Nations Millennium Declaration."[3]

In 2005, the DAC members of the OECD "agreed that South-South and triangular co-operation can improve the aid efficiency and effectiveness in emphasising ownership and inclusive partnerships".[4] On the "Forum on Partnerships for More Effective Development Co-operation" they also identified the need for a greater exchange of experiences and lessons learnt in order to promote triangular cooperation amongst the bilateral and multilateral donors. Hence, the relevance of triangular or South-South cooperation is becoming more important and is likely to continue to do so in the future.

Nonetheless, there is not yet a clear definition of what precisely is meant by triangular cooperation. Broadly speaking, one can subsume under it all "approaches that promotes partnership with various actors, which include traditional donors, multilateral agencies, private sector, academic institutions and Civil Society Organizations."[5] Within the scope of this project, however, trilateral or triangular cooperation refers to a kind of partnership where three groups of actors are involved: donors, technical assistance providers and the recipients.

The specific property is hence the participation of technical assistance providers that are regularly not from the same donor country but from intermediary countries, i.e. other developing or emerging countries. The selection of appropriate countries and institutions for this intermediary role is of utmost importance. On the one hand, it requires a relatively high level of expertise and know how of the country. On the other hand, there must be the political will and eagerness to cooperate and contribute to the development in third-party countries.

In addition to the technical assistance being provided by the "intermediary" country, there are several points that might be included into the concept of trilateral cooperation. They include the assistance in how to design and implement such projects to those countries that are increasingly becoming active in providing technical assistance. Also, the financial contribution of those countries may vary greatly and the compensations for their technical assistance might itself include technical assistance from the donor country. The specific

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3 Resolution A/RES/58/220

4 OECD (2005)

5 Mehta and Nanda (2005, p.3)

design of a project and such components ultimately determine the benefits of trilateral cooperation that can be realized. To provide a broad distinction of the different triangular approaches thinkable, one could distinguish three major models:

1. The “traditional” approach

   In this concept, the intermediary country only provides the technical assistance while the donor provides the financial resources. This approach only realizes some advantages mentioned below, while the legal construct is the most simple since there is regularly no agreement on government-level between the first two countries needed.

2. The modern “equal-part” approach

   Here, both donors provide technical assistance including financial contributions, regularly on an equal basis. The project is hence executed based on mutually agreements between all participating countries. Frequently, the “intermediary” country might be interested in receiving some assistance in the execution of similar projects as compensation in order to strengthen its future donor capabilities.

3. The modern “channel-through” approach

   In this case, the donor designates some part of the project execution, financing, and management to the “intermediary” institution. While this approach has the potential to reduce the administrative procedures and effectively use the “intermediary’s” capacities as donor country, there are high requirements for the political willingness and organisational capacities.

As the first model is only a very starting point for triangular cooperation, this study and also the discussions concentrate more on the latter two. Since they require the development of own donor institutions and mechanisms in the “intermediary” countries, this holds specifically for the cooperation with emerging donor countries.

While a number of developing countries like Brazil, China, Chile or India have embarked independently on systematic sharing knowledge on certain fields, major donors have revised or are revising their development policies with potential countries to employ trilateral projects with. For instance, UN’s TCDC has defined a list of so-called “pivotal countries"[6] which considers potential candidates for this innovative approach for development cooperation. Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Peru, and Trinidad&Tobago are included. Somewhat different, but also having implications in this direction, German development cooperation identified certain "anchor countries" (see below) with which development cooperation should be thought different than traditional.

Triangular and horizontal cooperation

Both approaches are closely related. Triangular cooperation refers to the technical cooperation among two or more developing countries that is supported financially by northern donors or by international organizations. Horizontal or South-South cooperation, on the other hand, is a broader concept because it covers a very wide range of collaboration among developing countries in three dimensions: political, economic and technical. It builds on reciprocal sharing of experiences, knowledge and technologies based on a commonly negotiated agenda. Thus, trilateral refers to the specific context of technical cooperation while horizontal cooperation is a broad concept that can be applied to various fields. Trilateral cooperation can be seen as supporting local horizontal structures through a third party institution. For that reason, the trilateral cooperation approach of donor countries and institutions fits the major aim of horizontal cooperation in the field of technical cooperation.

Advantages and Disadvantages

There are some very relevant advantages of triangular cooperation that can be realized in this cooperation approach. They include regularly lower costs, a better usage of existing capabilities in developing countries, a more appropriate technology for the recipient country, reduced forced ties to the donor country and a potential reduction of conflicting donors' policies. If the cooperation is on a regional basis, e.g. within Latin America, at the same time as the regional cooperation is being strengthened, barriers of different languages and cultural understandings can be reduced.

The lower costs occur mainly due to the fact that experts of developing or emerging countries are only about one third of the costs of an expert from an industrialized country or lower travel expenses etc.[7] Regarding the more appropriate technology, the role of intermediary technology has been highlight in recent years. Besides, the similar economic

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6 Ekoko and Benn (2002, p.125) or visit http://tcdc.undp.org/faq.asp

7 Ekoko and Benn (2002, p.122)

and social circumstances would allow a project of more appropriate nature to be designed. Trilateral cooperation also allows for an optimum utilisation of knowledge, skills and techniques available in developing countries, which leads to a greater efficiency of development assistance. It can help reducing tied-aid conditionality and sometimes even reduce the incoherencies or conflicting policies brought in by different donors.

Triangular development cooperation is also meaningful for the relationship to the contributing developing or emerging countries: while particularly the bigger emerging countries become of lesser relevance for the traditional development assistance, they become strategic partners for development. This reflects their becoming more relevant role in strategic fields of global governance including global public goods and the MDG agenda.

When applied in a regional context such as Latin America, there are some additional benefits that can accrue from trilateral cooperation: The cultural similarities can reduce the discrepancies of understandings of the partners involved. Specifically, the predominance of the Spanish language facilitates the project implementation (e.g., conferences, trainings, workshops) and further exchange of the participating people. As well, the regional cooperation is strengthened whereby future cooperation and dissemination of project results is facilitated. This holds specifically for already established regional integration initiatives like the Mercosur.

On the other hand, there might be some disadvantages or barriers to the implementation of triangular or horizontal cooperation: One could be lesser political commitment in donor countries than for the traditional bilateral approach. For the recipient countries, there could be found lower levels of confidence in the skills and techniques available in other developing countries or negative attributes like lack of professionalism may be a cause of concern. On the political level, there might be another barrier since policy makers and bureaucrats may not be too supportive to the idea of receiving technical assistance from other developing / emerging countries. To become a project of this type successful the willingness and support of both donating and recipient institutions has to be seriously into account.

Summing up, trilateral cooperation has various advantages over the traditional, bilateral approach. It can help to build up the horizontal cooperation among developing countries. From the donor perspective, especially facing stagnating funds of Official Development Assistance (ODA), it can be more cost effective to seek to transfer to other countries the capacities already developed in some developing countries. Thus, the promotion of trilateral development cooperation can be of great help by increasing the efficiency and effectiveness of aid drastically. However, there are some preconditions to make this approach a successful one: The donor governments need to show genuine commitment to development and poverty reduction because it partly could de-link their assistance programmes from their national politics. The recipient governments also need to appreciate the importance of trilateral development cooperation. Accordingly this study includes the policies and strategies of the intermediary and recipient countries in chapter five, after looking at the policies of the relevant donors in the specific field of natural gas metrology.

3.1 Relevance of trilateral cooperation to different actors

3.1.1 Organization of American States (OAS)

The OAS and specifically its development cooperation arm, the SEDI (Executive Secretariat for Integral Development) put special emphasis on horizontal cooperation. As a regional political body, it „encourages the transfer of know-how and the exchange of information and experience among member states".[8] For the OAS, horizontal cooperation is not a new concept, since the General Assembly of 1987 already reiterated the importance of horizontal cooperation developed within the framework of the organization.[9]

Restated in 2001 in the Declaration of Lima, the Ministers and High Authorities of Science and Technology agreed that they would "encourage the establishment of shared laboratory infrastructure that promotes research and horizontal cooperation, linked with metrology (…) and other relevant areas to provide access for the region's less developed countries"[10]. It hence specified the proclamation of the declaration of Lima saying that "we will join efforts to (...) promote the harmonization and coordination of science, technology, engineering, and innovation programs implemented by various bilateral and multilateral organizations in order to achieve the best results in applying available resources"[11]

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8 OAS (1997)

9 AG/RES. 857 (XVII-0/87)

10 OAS (2004c, p.3)

11 OAS (2004b, p.3)

Accordingly, three programs/funds for horizontal cooperation in Latin America and the Caribbean had already been initiated between 1992 and 1995 with the Governments of Mexico, Brazil and Argentina (OAS 1997).

The OAS perceives some characteristics of its organization to be beneficial for this type of cooperation. Firstly, the OAS regards the existence of working ties with institutions in all the member countries as very important as a channel for disseminating offers of cooperation and identifying demand. Additionally, the OAS' infrastructure in the member countries allows for initiatives being planned between the country lending the cooperation and one or more countries requesting it. Further advantages of the OAS regarding horizontal cooperation are related to the operational level of projects. Technically, the fund's mode of operation is determined through an agreement between the country lending cooperation and the General Secretariat. This aims at guaranteeing the rapid and timely administrative management needed to carry out cooperation activities needed for such a fund to be successful. One specific instrument of the OAS, the Special Multilateral Fund FEMCIDI was specifically developed to optimize the programming of available resources. It supports both projects that involve only one country and regional projects with at least three participating countries.

Generally, the OAS as a regional body puts emphasis on horizontal cooperation in order to foster the intra-regional exchange and to maximize the impact of its funds contributed to specific areas of cooperation.

3.1.2 German Development Cooperation (BMZ, PTB, GTZ)

The development cooperation of Germany follows the guidelines of the Federal Ministry for Economic Cooperation and Development (BMZ). Trilateral cooperation means for the BMZ that a partner country acts as donor to another country while the BMZ itself contributing to this cooperation.[12] In 2004, it accentuated its role particularly for development cooperation with what it called "anchor countries". These are countries, that "due to their economic weight and political influence, they are playing a growing role in their respective regions, and also increasingly on a global scale, in defining international policies and also for the achievement of the Millennium Development Goals (MDGs)" (BMZ 2004, p.3). In Latin America, Brazil and Mexico are considered as being anchor-

[12] The German Technical Cooperation (GTZ) uses the term "tripartite cooperation" in a different context. Here, it refers to a mode of cooperation through GTZ International Services (IS), where it receives a contract from one country to implement a project in another country.

countries and as such of particular interest for German development cooperation. Given their unique role for their respective region, cooperation with them should aim at a strategic partnership.

Specifically in the sector of scientific cooperation, the activities offered have to take into account the countries' specific needs regarding the access to scientific and technological knowledge and relevant contacts in industrialized countries. Therefore, the role of technical cooperation, "as a broker of knowledge and "know-how gate" to key competencies needs to be increased".[13]

3.2 Trilateral cooperation in metrology

Scientific and technical cooperation in general exhibits some unique characteristics that make trilateral cooperation a promising approach.

One reason lies in the heterogeneity of countries. Anchor-countries like Mexico and Brazil, often have a number of industrial growth centres as well as centres of innovation of international importance. Thus, they can provide sophisticated knowledge and expertise in these sectors. This allows other donors to cooperate with countries in the region by fostering the mutual cooperation and knowledge exchange amongst the countries in the region. The BMZ hence pursued to develop „attractive programs for anchor countries' scientific and technological systems (e.g., in the field of renewable energy sources, environmental technology). More systematic support should be given to the networking of scientific/technical institutions, research institutions and think tanks in Europe and Germany on the one hand and in anchor countries on the other"(BMZ 2004, p.8).

As Stamm (2004, p.22) points out, „the interconnection of development cooperation and scientific-technical cooperation and the cooperation with the private sector is of particular relevance to the advanced anchor countries Brazil and Mexico". Stamm (2006, p.41) argues, that trilateral cooperation is suitable particularly in the case of competences of both donors that can be complemented in the development of weaker partners. As an example, he sees the planned cooperation between the German PTB and the Brazilian INMETRO with the aim to contribute to the development of the quality infrastructure in the South African Development Community (SADC).

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[13] BMZ (2004, p.11)

Specifically in the sector of metrology, the important international and regional comparisons on different levels from laboratories to the National Metrology Institutes (NMIs) benefit from regional cooperation projects. Additionally, the exchange of expertise and practice in differing fields can lead to an improved local experience and knowledge base.

Thus, German PTB puts a special emphasis on regional cooperation and south-south cooperation. The strategy of the department for Latin America[14] explicitly points on the role of regional centres of competence that provide services to the entire region, ultimately leading to a self-contained structure of quality infrastructure. The contribution of other donors becomes hence to provide know-how that is not yet present in the region. Therefore, the specific local needs have to be thoroughly assessed.

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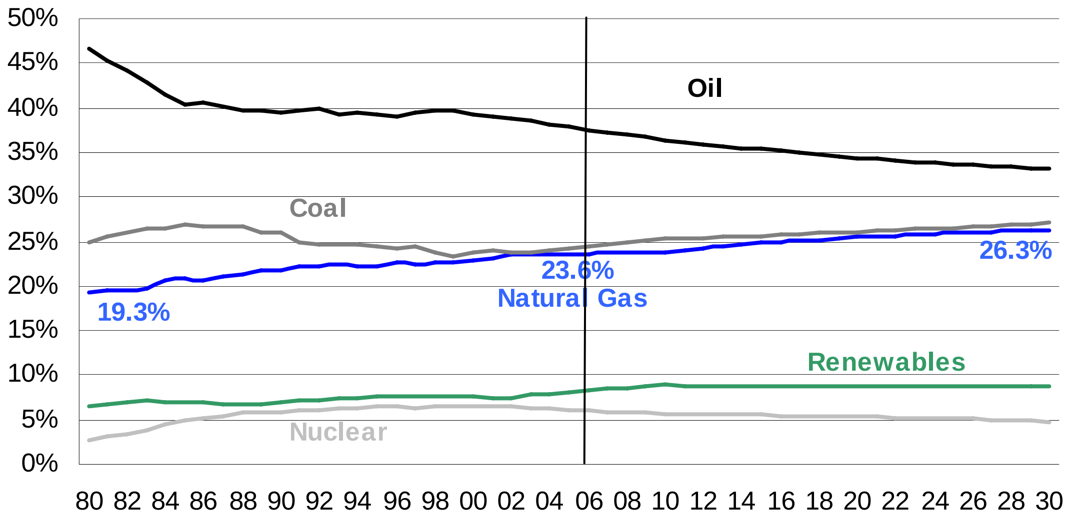
[14] PTB (2004)

4 The Natural Gas Sector

The world energy consumption has steadily increased during the last decades and will continue to do so. According to the International Energy Agency (IEA), it will rise by another 51% until 2030, mainly due to the rapid economic growth in emerging countries like India and China. This development is likely to continue even though the prices for different sources of energy are still increasing posing great risks to the energy-dependent countries. On the other hand, the rents generated in the resource abundant countries are now becoming even more relevant factors for these states and their economies.

Concerning the composition of energy consumption, it has been observed that the importance of oil and coal is stagnating or decreasing, even though at a relatively high level. Nuclear energy and renewable sources on the other end are becoming more relevant however starting from low levels. The importance of natural gas has significantly increased during the last decades making it the fast growing energy resource during the between 1972 and 2002 (see Figure 1) and its share is predicted to rise to over 26 % by 2030. By then, it will have caught up with coal as the second most important source of energy.

Figure 1: World marketed energy use by fuel type, 1980-2030



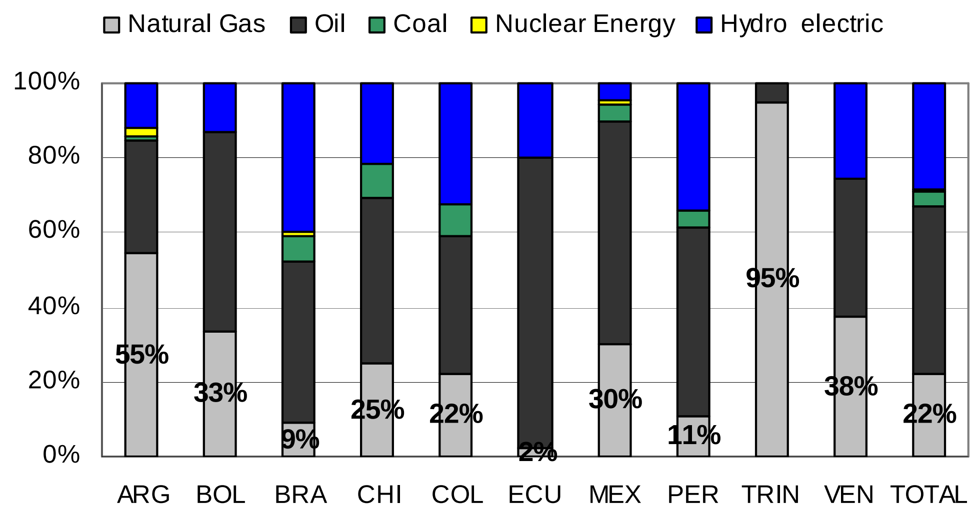
Source: DOE / EIA (2006b, p.8)

The reasons for this shift in energy consumption and hence production are the manifold: The relative abundance of gas and its geographical not as concentrated distribution (esp. in comparison to oil, where nearly 70% of the resources are located in the middle east) provides the basis for increased supplies on the world energy markets. Additionally, technological advances in transporting and storage of gas have reduced the cost of transporting gas from the areas of production to the centres of consumption. The major reason for this preference for gas however stems from the fact that natural gas is burned much more efficient than oil or coal, e.g. in power generation. This shift also reflects growing concerns about ecological issues that favour the use of gas because it emits less carbon dioxide and other substances like nitrogen oxides (NO_x) than oil.[15]

Besides the growing importance of gas, its relevance to the international energy markets remains relatively low. The physical properties of gas make it extremely difficult and costly to transport it over longer distances. Its density, which is about 1/1000th of that of crude oil, makes its transportation very expensive. The share of total transportation costs is as high as 50 % of the customers' price as compared to 5 to 10 per cent in the case of oil. As a result, about 85 % of the total production is consumed locally and there is no explicit world market for natural gas (like for crude).[16] Therefore, the negotiations and possible conflicts arising about gas are mostly of regional scope, as the debate about the nationalisation of Bolivian natural gas resources showed.

4.1 Natural Gas in Latin America

Figure 2: Share of fuels in total primary energy supply in 2005



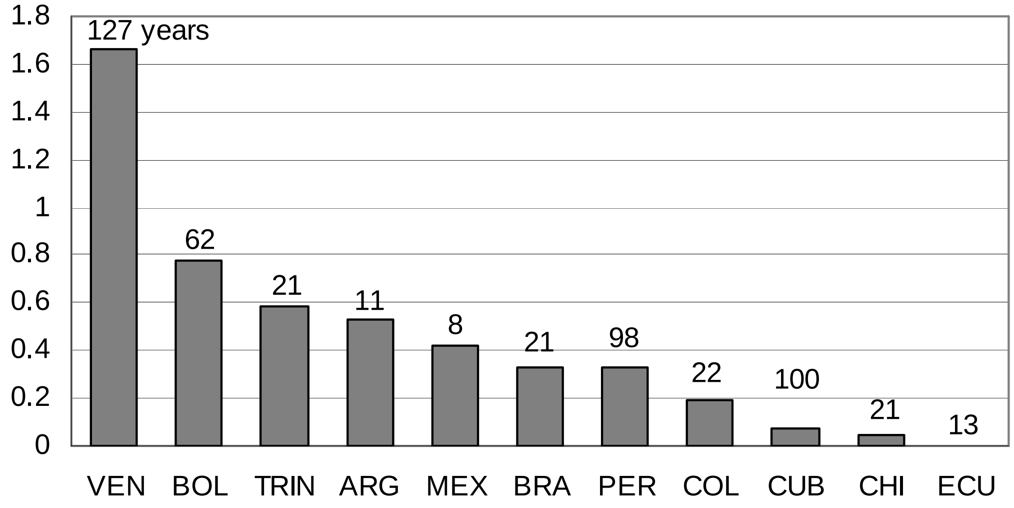
Source: BP (2006, p.41) and IEA (2006).

15 CEPAL (1999, p.138)

16 Recent developments in the production of Liquefied Natural Gas (LNG), which can be shipped to the importing countries, are providing opportunities to export even over longer distances. Nevertheless, the costs remain comparably high. This aspect is explored more in detail in chapter 4.5.

In 2000, natural gas contributed 22 % to the total primary energy supply of Latin America up from 18 per cent in 1990.[17] However, the differences between the countries are remarkable ranging from less than five per cent to over 95 % in the case of Trinidad and Tobago.

Figure 3: Proven reserves of gas (in trillion m^3) and reserves-to-production ratios (in years) in 2004



Source: OLADE / SIEE (2005, p. 7). The reserves-to-production ratios predict the number of years estimated reserves will last at current levels of production. However, due to new discoveries of oil fields and so-called probable and possible reserves, this does not necessarily mean that the resource will be exhausted within this period.

In general, gas resources have been discovered so far in all South American countries[18], but also in Mexico, Guatemala, Barbados and Trinidad and Tobago. The combined resources account for about 4.1 % of the world's proven reserves.[19]

And there are notably new explorations of gas fields under way as for instance the Camisea field in Peru. Accordingly, during the Nineties, the proven reserves have increased by 50 per cent for entire Latin America. This increase in the proven reserves, which is likely to continue, together with a shift in the demand for energy towards gas make this sector increasingly important in the future both for the states and private enterprises.

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[17] IEA (2003, p.40)

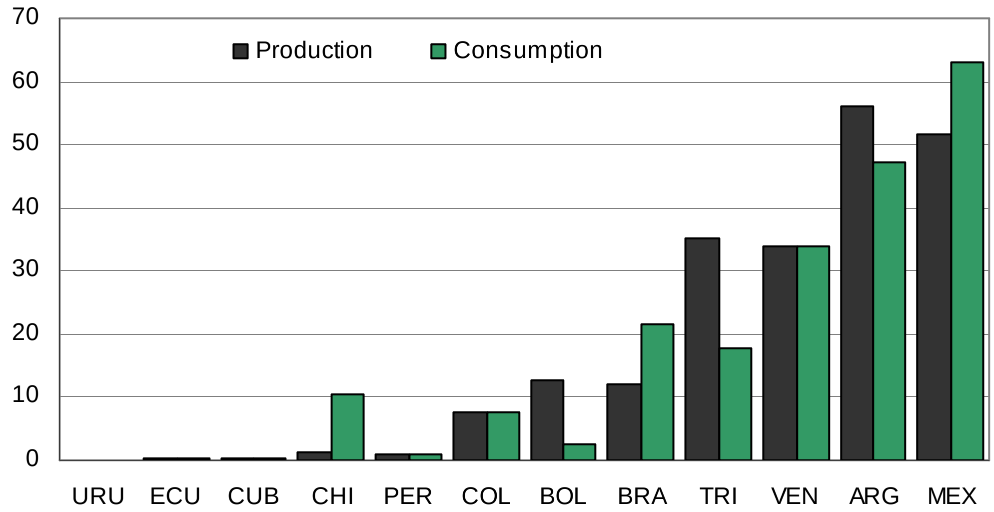
[18] Except for Guyana, Suriname and French Guiana

[19] BP (2006, p.22) Latin America as in this paper is being comprised by all South-American and Central American countries, the Caribbean and Mexico. In all figures and tables, the countries left out are that only those which are negligible in the respective context.

4.2 Production and Distribution

The levels of production of natural gas vary greatly between the Latin American countries as is depicted in Figure 4.

Figure 4: Production and consumption of natural gas (in billion m^3) in 2004[20]



Source: DOE / EIA (2006c, tables 1.3 and 2.4)

In general, the value chain of natural gas can be divided into three sectors: The *upstream* comprises the exploration, extraction and production. Hereby, exploration refers to how natural gas is found, and how companies decide where to drill wells for it; extraction stands for the drilling process and how natural gas is brought from its underground reservoirs to the surface; production means the processing and purification of natural gas, e.g. through the removal of oil, condensate, and water and the separation of natural gas liquids. The term *midstream* refers to the transportation and storage of natural gas. It includes the transportation from the wellhead and processing plant to the regional distribution networks and the storage facilities. The *downstream* finally includes the transportation to the end users and distribution.

The gas is transported via (domestic) pipelines, which are regularly operated by a regional or national body, to large consumers such as power plants or the so-called city gate. There,

20 Generally, the production comprises only the marketed production. From the total amount of gas drilled, some part is flared (burned at the wellhead), vented (released into the atmosphere) or reinjected (mainly to maintain the pressure for oil drilling). These measures are including used in the case of lacking transportation capabilities. While in South America some 6 per cent of the production is flared or vented, this figure reaches over 18 per cent for Peru and Brazil (IEA (2003, p.29).

the local utility distribution company takes over and transports the gas to the final consumers. Regularly, the different sectors are operated by separated institutions even though there are often close ties between the producing, transporting and local distributing companies.

Since the 1990ies, the production side of the natural gas sector has been liberalized in most of the countries leading to the engagement of foreign companies in this sector and an increased competition in this sector. Accordingly, in the most countries there are today several gas producing companies active. However, the transportation and distribution of natural gas exhibits criteria of a natural monopoly since it is the most economic way to transport and distribute gas only through one pipeline or distribution net. Hence, competition in this sector appears to be relatively low. The close links to the producing companies and the somewhat still remaining influence of the state on the sector led to a structure that can be regarded as partly liberalized.

Looking at the specific countries, the development was comparably in the sense that the liberalisation was initiated between 1992 and 1997 through a new gas sector law followed by the installation of a regulative body and foreign companies, both from other Latin-American countries and overseas, investing into the market of production of natural gas. Nevertheless, nowadays, the structures for energy in general and natural gas in specific exhibit a great diversity of structures, markets, regulatory settings and pricing mechanisms.[21]

For instance, in **Argentina's** reform dating back to 1992 led to the acquisition of state-owned YPF by Spanish Repsol S.A. in 1999. It controls about 51% of the Argentinean gas production and is also active in other Latin American countries making YPS-Repsol the company that controls the largest resources on the continent. Argentina's network of pipelines and distribution networks is well-developed and there are several private companies active in this field so that the sector can be regarded the most liberalized one in Latin America.

In **Bolivia**, the reforms started in 1994, allowing a 50% stake of Yacimientos Petrolíferos Bolivianos (YPFP) to be sold. The liberalisation included the creation of five separate regional distribution companies and led to a strong increase in the production of natural gas also based on the tenfold increase of proved reserves between 1997 and 2002.

[21] The following is mainly based on CEPAL (2004, pp.64) and IEA (2003). The countries not included in this list are the countries of Central America, the Caribbean, Uruguay, and Paraguay. They were left out since for them, natural gas plays no or only a very minor role (except for the case of Trinidad and Tobago).

Particularly, the opportunity to export natural through the 3,200 kilometer Bolivia-Brazil pipeline (Gasbol) has attracted many large regional and international companies to Bolivia. However, the nationalisation of all gas reserves as announced by president Evo Morales on the 1st of May 2006 put future development into question. Nevertheless, long-term perspectives are bright given the countries' vast reserves.

In **Brazil**, the opening of the upstream occurred not as fast and wide-reaching as in other countries. Petrobras still controls the over 90 per cent of proven reserves and operates the pipeline to Bolivia. Including, it manages the transportation network of natural gas and is the largest wholesale supplier. As by law, it has to be controlled by the state which still controls 55.7 per cent of the company. Most of the reserves are found offshore or in the Amazonian States which makes exploitation and transportation difficult. Additionally, the distribution network is still relatively small though many projects were begun by the government to increase the pipeline structure. By now, the overall importance of natural gas for Brazil is only minor contributing as little as six per cent to its energy supply.

In **Ecuador**, the only large-scale natural gas project is the Amistad field, located in the Gulf of Guayaquil. Since there is only negligible domestic demand or support infrastructure for natural gas, the entire production flows to a 130 megawatt gas-fired power plant. Ecuador's oil industry also flares a significant amount of natural gas from its operations, as there are no systems in place to capture it.

In **Colombia**, the government aims at increasing domestic natural gas use. Chevron is the largest natural gas producer followed by some consortiums of foreign companies. There are several projects underway to increase production and lead to exportations to Venezuela for a certain period before the direction of trade will eventually be reversed.

State-owned Pemex holds a monopoly on natural gas exploration and production in **Mexico**. Including, it operates its 10,800 kilometer pipeline system and controls most of the distribution network. While its gas production is relatively spread throughout the country, it is mostly (81 percent) associated with oil extraction (associated natural gas). It currently has ten natural gas connections with the United States and two LNG regasification plants are under construction highlighting its dependence on imports.

In **Peru**, the production of gas was limited to the northern region of Piura. The 1984 discovery of the Camisea field, however, will increase the capacity enormously (some 255 billion cubic meters of proven reserves). The exploitation of the Camisea field will executed by a consortium led by U.S. based Hunt Oil Corp. Additional financing for the 1.3 billion US-$ project comes from the CAF and the IADB despite environmental concerns.

In **Venezuela**, the policy of aperture was stopped in 1998 when Hugo Chavez took office. The state-owned Petroleos de Venezuela S.A. (PDVSA) is still the major producer. However, the engagement of foreign companies in the sector of gas is not as limited as in the sector of crude oil. Accordingly, since 1999 when foreign investments in this sector were allowed, increasingly also foreign companies became active in this sector. The further development of the sector will eventually make Venezuela an exporting country via a pipeline that is currently being constructed between Colombia and Venezuela.

4.3 Consumption

The demand for natural gas still exhibits a steep rise in Latin America. As in the other regions of the world, this rise has been mainly occurred in order to meet the needs of power generation. Gas is becoming a preferred fuel in power generation mainly due to the technological developments that made gas-fired plants substantially more efficient and economical.[22] Additionally, the relatively low up-front investments that are required for those plants make it further attractive.

Besides power generation, the industry is one of the major consumers of natural gas. In the petrochemical and iron-and-steel industries, natural gas is used both as an energy source and as feedstock. In the petrochemical industry, methane is used in the production of methanol, ammonia (e.g. for the production of fertilisers) and hydrogen. In the iron-and-steel industry, natural gas is not only a source of heat, but may also act as a chemical reductor substituting for coking coal. In South America, the petrochemical sectors accounted for about half of industrial gas demand in 2000 while the iron-and-steel industry consumed about 20% of industrial gas demand.[23] But also other industries are increasingly using natural gas due to its improved and constant product quality, not producing ash content. For these reasons, it is often the preferred fuel in the glass, ceramic, and food and beverage industries.

Regarding the use of gas in residential, commercial and public buildings, the relevance is still minor (with the exception of Argentina), mainly due to the fact that there is no need for space heating on most of the continent. Ultimately, the use of compressed natural gas (CNG) as a fuel for road transport is increasingly becoming important for Latin America. Figure 5 shows the sectoral use as of 2001 for Latin America. Specifically the use of CNG as fuel for transportation is comparably high in Latin America, as Table 1 implies.

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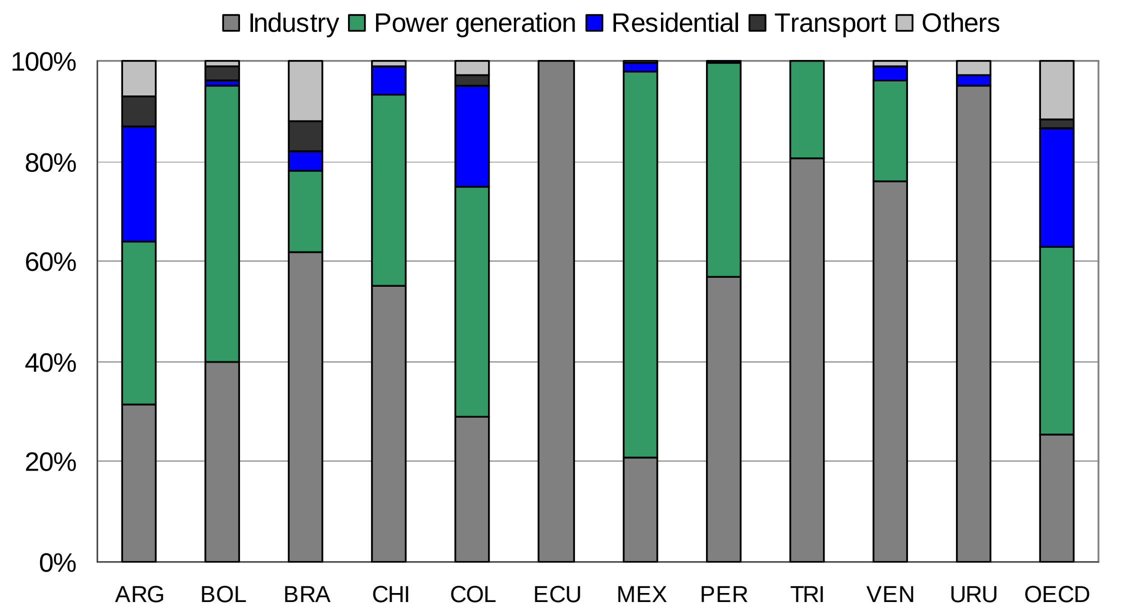
[22] IEA (2003, p.37)

[23] IEA (2004, p.44)

Figure 5: Sectoral use of natural gas in Latin America, 2001



Source: based on CEPAL (2004). The data for Ecuador and Trinidad is from IEA (2003, p.45) and refers to the year 2000. The values for Mexico and the OECD are taken from IEA (2006) and are for 2003. "Industry" includes petrochemical industry and other related processing.

Table 1: The use of natural gas for transportation in latin America

Country	Vehicles	Rank (worldwide)	Refuelling Stations
Argentina	1,459,236	1	1,400
Brazil	1,117,885	2	1227
Colombia	60,000	11	90
Bolivia	57,900	12	87
Venezuela	44,146	14	149
Chile	5,500	29	12
Trinidad & Tobago	4,000	31	13
Mexico	3,037	32	6
Peru	1,831	33	2
Cuba	45	37	1

Source: based on figures from the International Association of Natural Gas Vehicles (www.iangv.org/content/view/17/35/). Due to data availability, the figures refer to different years ranging from 2001 to 2006.

For instance, in Peru, the number of Natural Gas Vehicles (NGV) rose from 269 to 1831 only within the first six months of 2006. For Bolivia, it is expected to reach 250,000 by 2010. As it is evident from Figure 4, there are countries like Argentina, Bolivia and Peru that have a significant excess production while specifically Chile and Brazil are dependent on large imports of gas. The future development prospects of each country’s gas sector are dependent on both its reserves and its potential of the domestic market. The continent’s countries can thus be roughly grouped into four categories:

Table 2: Natural gas reserves and domestic market potential

		Domestic market potential	
		High	**Low**
Natural gas reserves	**High**	Argentina, Venezuela, Colombia, Mexico	Bolivia, Peru, Ecuador, Trinidad & Tobago
	Low	Brazil, Chile	Paraguay, Uruguay, Central America

Source: based on IEA (2003, p.56)

Looking at the actual development of the domestic markets, the situation in Latin America is still at an early stage. IEA (2003, p. 43) consider only Argentina and Trinidad and Tobago as having mature downstream markets. Their criteria are the market penetration also in the commercial and household markets. A number of Latin American countries constitute ‘young’ gas markets (Bolivia, Chile, Colombia, Venezuela and Brazil). In these countries, large infrastructure investments in the transmission and distribution network will still be needed. For Peru, Ecuador, Paraguay, Uruguay and Central America, the downstream gas market is still insignificant. For the case of Peru, however, it is worthy mentioning, that given its huge reserves, the Peruvian government is looking to implement a plan that will stimulate natural gas consumption in the country to help mitigate Peru’s high oil import bill. The plan targets public and private transportation, by converting vehicles to run on natural gas.[24]

4.4 Gas pricing

Since there is no huge world market as for crude oil, the prices and thus both expenses and rents are not easy to determine. If one looks at the import prices of the United States as a proxy (see Figure 10 in the appendix), however, the trend of rising prices over the last years is clearly visible. For the next decades, the price is expected so stay in the range

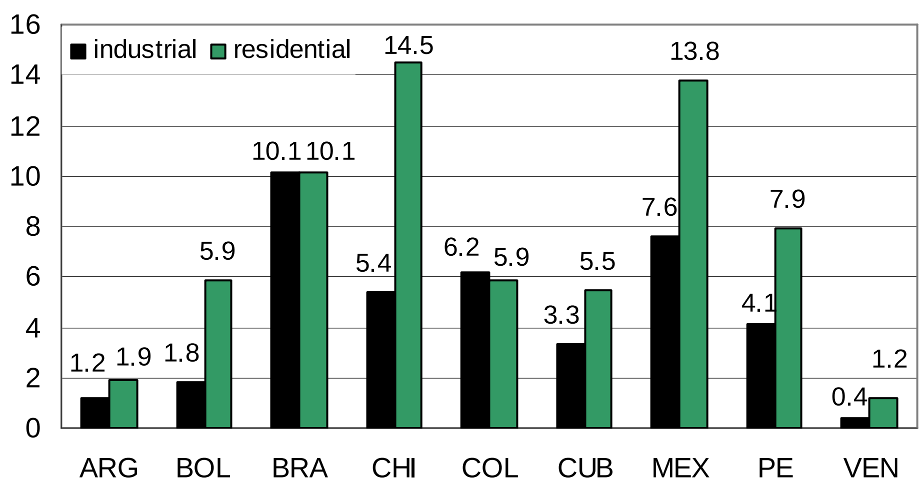
24 IEA (2006)

between five and ten dollars.[25] This is supposed to hold also true for other regional markets like Latin America.

For the end-users, however, the price not only depends on the market price but also on various policy measures such as subsidies and taxes that are in place in a specific country. Figure 6 shows that there are great differences between the Latin American countries both for households and industries. Additionally, most countries set up different pricing for industrial and residential consumers.

For the market development of natural gas, however, a competitive pricing is pivotal especially in the sectors where it competes with other fuels (steam raising, power generation). These sectors have the most price-sensitive demand given that gas is a substitute for other, lower-priced fuels like coal or oil.

Figure 6: Natural gas end-use prices for industry and households in 2004 (US-$ per million Btu)



Source: compiled from DOE / EIA (2006d) using market exchange rates to convert local currencies

In addition to the end-use pricing mechanism, the pricing along the value chain from the wellhead to the consumers is essential for the distribution of rents and thus the sector's development. There are essentially two approaches of pricing: the cost-based (or cost-plus) approach and the market-value netback approach.[26] The chosen pricing policy strongly affects the distribution on the resource rents between the producing company, the transporting entity and the final consumers.

25 http://web.worldbank.org/external/default/main?theSitePK=612501&pagePK=64218950&contentMDK=20722183&menuPK=627723&piPK=64218883

26 See IEA (2003, p.75) for an overview on gas pricing along the value chain.

4.5 Trade of Natural Gas

The trade of natural gas is limited by its gaseous nature. Worldwide, only a mere 26 per cent of total world marketed natural gas production is internationally traded.[27] It can be either transported via pipelines over-land or being shipped as Liquefied Natural Gas (LNG). The production of LNG requires huge investments in liquefaction plants, special vessels and re-gasification facilities at the importing country. The natural gas is thereby cooled to -163 degree Celsius when it becomes liquid and its volume is reduced to one 600th. The cooling process requires roughly one fourth of the energy contained in the gas. Still, it is very interesting for countries that rely heavily on imports and even is used to distribute natural gas in remote areas.[28] It accounts for roughly one fifth of total trade in natural gas. As of now, Trinidad and Tobago is still the only country in Latin America that possesses a liquefaction plant exporting some 14 billion cubic meters of LNG, mainly to the United States of America. Recently however, more Latin-American countries are planning to engage in LNG exports. Specifically, Mexico, Peru, Venezuela and Bolivia are about to export parts of their reserves as LNG since the overall production still outpaces regional demand. But by now, the exportation of natural gas via pipelines still dominates the sector.

The Latin American continent is already covered by a grid of pipelines that connect its countries mutually. The current and planned pipelines and the trade flows are depicted in Figure 9 in the appendix. As of today, only Bolivia, Argentina and Trinidad & Tobago are exporting natural gas. However, the development of the Camisea field in Peru will turn this country also into an exporting country. Specifically, a liquefaction plant is scheduled for 2006 or 2007 to produce and export LNG to Mexico and the United States.[29]

Moreover, the medium term plans of gas transportation via pipelines includes a pipeline from Venezuela to supply Colombia and pipelines between Venezuela and Trinidad & Tobago and Peru and Bolivia in order to produce LNG at the respective liquefaction facilities.[30] Hence, Venezuela is also about to become a natural gas exporting countries with exports directed to Columbia and the United States as LNG.

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27 UNCTAD (2006)

28 For instance, in Brazil, LNG is produced and transported with trucks to areas without pipeline access, e.g., Brasilia.

29 DOE / EIA (2006b, p.40)

30 CEPAL (2004, p.68)

Since Argentina and Trinidad & Tobago both have comparably mature gas downstream markets and an advanced metrology architecture in the gas sector, this report focuses on Bolivia and the upcoming exporter Peru. Both countries have large reserves to be used for consumption and exportation. Additionally, both countries are lacking an elaborate quality infrastructure for the gas sector (see chapter 5). These countries are explored in detail in this report.

Bolivia started exporting natural gas to Argentina in 1972. Exports to Brazil just began in 1999 at a 20-year take-or-pay contract of 10,080 million m^3 per year.[31] In 2004, the exports of natural gas accounted for 30 per cent of Bolivia's total exports.[32] However, the nationalisation announced by president Evo Morales on May 1st 2006, has put the future development into question. According to the decree, the companies have 180 days to accept new contracts whose terms will be set after a government audit. In the interim, the state's take from the two largest fields will rise to 82% from 50% thus boosting the government's annual gas revenue by $320m to $780m.[33] Currently, negotiations over raising the price from 3.8 to 7.5 per million BTU are taking place between the two countries.

Additionally, Bolivia had plans to export LNG to Mexico and the United States: In 2001, Repsol-YPF led a consortium to develop the Pacific LNG project, which would include a natural gas pipeline connecting an LNG export terminal at a port in Chile. However, the plan presented political problems due to a land dispute between Bolivia and Chile dating back to the 19th century. In 2003, the Bolivian government decided to move forward with the Pacific LNG project. This created waves of protests throughout the country and finally led to the resignation of President Sanchez. Since then, the government endorsed a plan to export LNG via a terminal in Peru, but the significantly higher costs of this alternative made many international investors turn away, leaving its future unclear.

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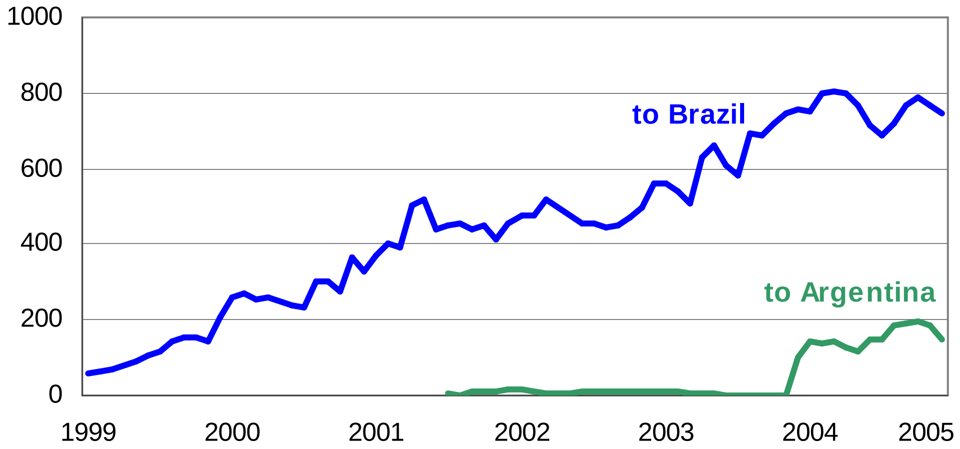
31 The actual exports in 2005 were however only 8,630 million m^3. Nevertheless, Brazil had to pay the full contracted amount.

32 www.mundoandino.com/Bolivia/Economy-in-depth

33 The Economist, May 4th, 2006

Figure 7: Bolivia's natural gas exports, July 1999 - June 2005 (million cubic feet per day)



Source: DOE / EIA (2006a)

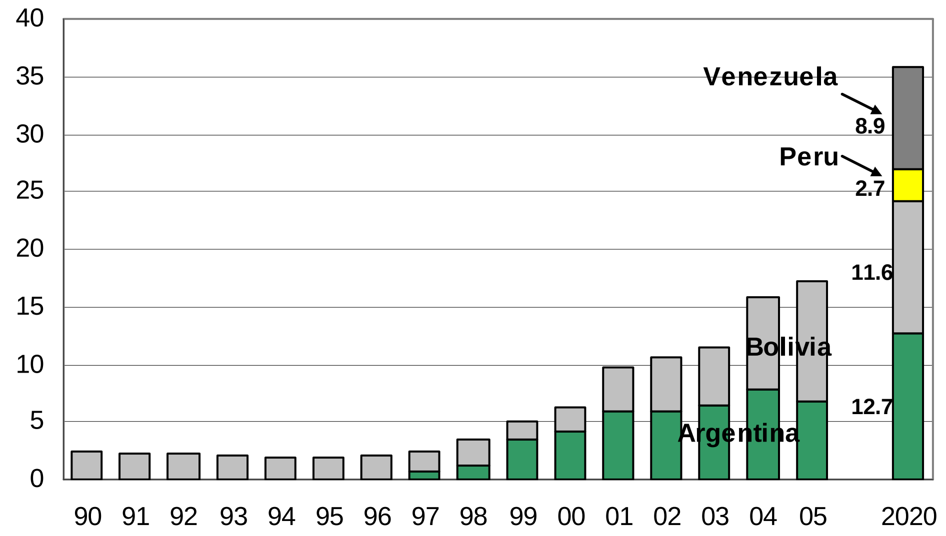
Peru's natural gas exports resulting from excess production will be transported mainly as LNG. The Peru LNG facility will have an operating capacity of 4.2 million tons (equivalent to 5670 million m^3) per year, with most of the production destined for the Western United States and Mexico. Peru including plans to build a pipeline to feed natural gas from existing natural gas pipelines to the LNG export terminal. The construction of the pipeline is expected to start in the latter half of 2006 and to be completed as early as 2008, with first exports leaving the terminal in 2009. Additionally, Ecuador's Ministry of Energy signed a Memorandum of Understanding with BPZ Energy in which Peru could export up to 1.1 trillion cubic feet of natural gas to Ecuador over a 15-year period starting from October 2006. Besides, there exist plans for exporting natural gas to Chile, both as LNG and via pipelines. Accordingly, Peru is estimated to export more than 2 billion m^3 from 2015 onwards.[34]

Overall, exportations from natural gas are increasingly becoming important for several Latin American countries since regional supply continues to exceed demand and the reserves are still increasing. In 2004, however, it accounted for only 14.7 per cent of the marketed production. This figure is expected to increase in the future once the new pipelines and LNG plants will enable the countries to boost exports. The overall exportations of Latin America nearly doubled from 16.0 billion m^3 in 2002 to 31.2 billion

[34] OLADE / SIEE (2006)

m³ in 2005 and are expect to further increase as depicted in Figure 8. Along with the rising prices for natural gas, this will lead to great market opportunities and fiscal benefits and thus further increase the relevance of this sector for the continent.

Figure 8: South America's natural gas exports in billion m³, including forecast for 2020



Source: DOE / EIA (2006c), BP (2006, p.30 for 2005), OLADE / SIEE (2006, forecast for 2020)

4.6 Metrology for the Natural Gas Sector

To measure the energetic of gas transported or consumed, various parameters have to be measured. Starting with the actual volume of gas transported, it is adjusted using measurement of temperature and pressure to calculate the norm volume since these two parameters change the actual volume measured. Thereafter, the energetic value that lastly determines the value is calculated taken into account the calorific content of a defined amount of the natural gas. Natural gas measurement hence incorporates for areas: flow, pressure, temperature and calorific content. Since the final determination of the energy amount transported takes various steps, the combined uncertainties of all parameters necessary to compute this value have to taken into account. This highlights the role of measurement uncertainties at each step.[35]

The majority of all volume measurement used in the world today is performed by two basic types of meters: positive displacement and inferential. Positive displacement meters,

[35] Peignelin et al. (1986, 74)

consisting mainly of diaphragm and rotary style devices, are generally for measuring lower volumes at lower pressure. This includes residential, commercial and small industrial usages. The gas usually has a pressure of up to four bars thus being referred to as **low-pressure** and volume flows up to approx. 4000 m^3/h. On the low pressure sector, metrology aims at contributing to the consumer protection. The consumers, be it households, commercial or industrial customers, should be prevented from incorrect invoices. Regularly, countries included requirements for the gas meter equipment and its calibration into their legislation. Thus, fair and transparent access to natural gas can be ensured both for households and industrial clients. With gas usage becoming increasingly important and the gas distribution grid being extended, it is becoming more relevant in many Latin American countries.

At the **high-pressure sector**, it is highly relevant verify the performance of custody transfer meters, which are used to measure the quantity of gas at the points where the ownership changes. For example, custody transfer could take place at the transfer from pipelines to local distribution companies. Here, the measurement is frequently not regulated by law but voluntarily executed through the industries involved. Measurement of so-called high-pressure natural gas at the custody transfer points from the wellhead to the city gate or large-scale industrial customers is done using inferential meters. The three main inferential meters used are orifices plates (following the ISO 5167 standard), ultrasonic, and turbine meters. While turbine and ultrasonic meters exhibit the lowest possible relative uncertainty (0.5%), orifice plates are of lesser accuracy (typically above 1.5%). However, while the former methods require initial and periodic calibration, the latter requires only a certification of compliance with the ISO norm when installed and no frequent calibration. The disadvantage of orifice plates is the pressure loss that occurs that finally leads to higher costs for transportation. Nevertheless, they still account for a huge part of high pressure meters installed in the upstream (for instance, in Mexico, 68% of all extracted natural gas is measured through orifice plates while turbine and ultrasonic meters account for 16% each.[36]

When the actual volume of gas that passes the meter is measured, for an accurate measurement, the temperature and pressure have also to be determined for the calculation of the volume at normal conditions.

Then, the energetic value can be determined by using one of the following methods: Firstly, the composition of a specific natural gas (e.g., from one well head at a specific time) can be determined using gas chromatography. Then, the energetic value can be

[36] Arias Romero (2006, p.18)

calculated using a theoretic model of the energetic values of the components and their respective shares in the natural gas. This indirect method is most commonly used due to its simple application even though the uncertainties at the field level reach up to three to five percent. Secondly, the energy of the combustion of a specific amount of the natural gas can be measured using a calorimeter. This direct method could lead to more accurate results; however, it is less practical than gas chromatography which can be used directly in-line. It is barely used nowadays in the industry.

4.6.1 Impact of natural gas measurement

In financial terms, improved measurement capabilities have two sides: On the one hand, there are costs associated with the services provided by laboratories etc. On the other hand, the large volumes of gas traded make an even seemingly small measurement error such as 0.2% leading to immense potential financial impact.[37] To give an example for the economic relevance of measurement, consider the case of the Bolivian exports to Brazil: Assuming a mean calorific content of 37,000 Btu per m^3 and a price of 2.50 US-$[38] per million Btu, the total annual sales in 2005 were about 0.8 billion US-$. Hence, a mere measurement error of 0.2% combined of all measurements leads to an additional cost of 1.6 million US-Dollars per year for the disadvantaged side (including the company involved and the state collecting royalties and taxes). Overall measurement error at the border measuring station using an orifice plate of about 2 up to 5 per cent of uncertainty thus means some 16 to 40 million US dollars per year!

The rapid escalation in natural gas prices magnifies the consequences of inaccurate and inadequate natural gas measurement. Therefore, the adequate measurement of quantity and quality of natural gas is becoming even more important. Specifically, the complex network for gas transportation and trade of energy is demanding more accurate measurements of gas volumes.[39]

Hence, the reduction of measurement errors leads to a more transparent transaction, potentially reducing points of dispute and ultimately leading to a more efficient allocation of resources. Besides the benefits for the companies involved, measurement at the high pressure sector is also of great public interest. Thus, to calculate the value of the traded

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[37] See Mantilla and Flegel (2001, p.30) or Napper (1986, p.59) for an exemplary calculation of the financial impact.

[38] That is the price at which Bolivian Gas is marketed in Brazil.

[39] Mantilla and Flegel (2001, p.29)

amounts of gas between the countries, it is indispensable to have a system of audited measurements of gas flows and quality for the institutions and companies acting in this field. The first point of measurement is usually also the royalty measurement point used to calculate taxes and royalties. Since rents generated through gas production can represent a substantial share of the budget and foreign exchange revenues, measurement becomes crucial for states with large resources.[40]

But exact measurement is also relevant to the development of the national downstream sector. Since the pricing of natural gas is increasingly being executed by deducting costs from the market price to consumers, the determination of this price is of utmost importance. Therefore, the market value of natural gas has to be determined, taking into account differences in heating value and efficiency in comparison to other fuels (IEA 2003, p.76). Including, the determination of volume and heat value is pivotal to set the prices for gas transportation and distribution (CEPAL 2004, p.69).

Overall, natural gas measurement has relevant impact on the fair distribution of the resource rents between the producers and consumers. Including, it is important for the determination of fair and competitive market prices for producers, consumers and the transporting and distributing companies and institutions. It contributes to transparency in the natural gas sector and includes legal regulation and the position of the state in the sector. Thereby, it can lead to enhanced transparency and accountability in the public and private institutions of the sector. This finally leads to better governance and consumer protection and better access to energy for households and industries.

4.6.2 Requirements for the quality infrastructure

At some points of the gas chain, measurement is mandatory (due to legal or statutory requirements or operational necessity), whereas at other points, measurement should or could be voluntarily done for some reason.[41] Hence, metrology is on the one hand relevant for legal aspects of the gas sector, such as calculating royalties or safety regulations and consumer protection. This area of **legal metrology** has various goals such as fair trade, full benefits to exportation, full collection of government's taxes, and protecting consumers from being deceived by inaccurate measurements. It includes the mandatory

40 Even though there is a huge debate on the “fair share” a state should obtain from resource rents, it is said to be around 45 to 85 per cent of the project net cash flow (www.gasandoil.com/ogel/samples /freearticles/article_27.htm)

41 Hinton (1986, p.56)

control of measuring instruments through verification and the type approval e.g., for gas dispensers or household gas flow meters.

On the other hand, metrology can be important for the companies active in the sector like the producers of natural gas, pipeline operating companies, and local distributors. Here, **industrial metrology** helps to enable the companies to accurately determine the values of gas transported between different entities at custody transfer points and thus leads to a fairer competition in the sector. It is in the very self-interest of these companies being able to measure as accurate as possible so that there are usually no regulatory requirements. Including, industries that are consuming large amounts of gas like power generation or steel processing rely on exact measurement due to their high gas receipts.

In general, the quality infrastructure covers the aspects of metrology, standardization, testing, certification and accreditation. This study focuses on the requirements in the area of natural gas and concentrates mainly on the services that the respective National Metrology Institutes (NMI) ought to provide in these areas. They include

- Provision of primary standards in all the areas incorporated (gas flow, pressure, temperature and calorific content) to ensure traceability
- Ability to execute type approvals, e.g., for natural gas dispensers
- Provide services such as initial and periodic verification of dispensers
- Calibration of metering equipment
- Verification of compliance to standards or norms (e.g., ISO 5167 for orifice plates)

For the quality infrastructure of a given country, this means, that it has to provide these services as it is required by the actual development and future prospects of the natural gas sector. The relevance of the national infrastructure can be regarded as very high even though some services can also be provided by international companies. One example is the calibration of volume meters and the importance of traceability: even though most meter manufacturers perform checks on their meters prior to shipping, these checks only evaluate the general performance of the meter without consideration of installation factors and other ancillary devices. Moreover, over some period of time, the meter performance may change as a result of the operating factors the meter is exposed to. These include the operating environment, the condition of the gas it is measuring, the level of maintenance received and the life span of the meter.

Another example what importance metrology plays facing new developments is the role of Liquefied Natural Gas (LNG) for exportation and Compressed Natural Gas (CNG) for transportation. The rising importance of these two forms of natural gas leads to the requirements for certification of gas dispensers, type approval for gas meters for these fuels and primary standards and calibration services for cryogenic liquids flow (e.g., for coriolis mass flow meters or LNG turbine meters). This highlights the role for a competent metrology that adapts to the upcoming and existing needs of a country to develop the services needed.

5 Technical cooperation on metrology for the natural gas sector in Latin America

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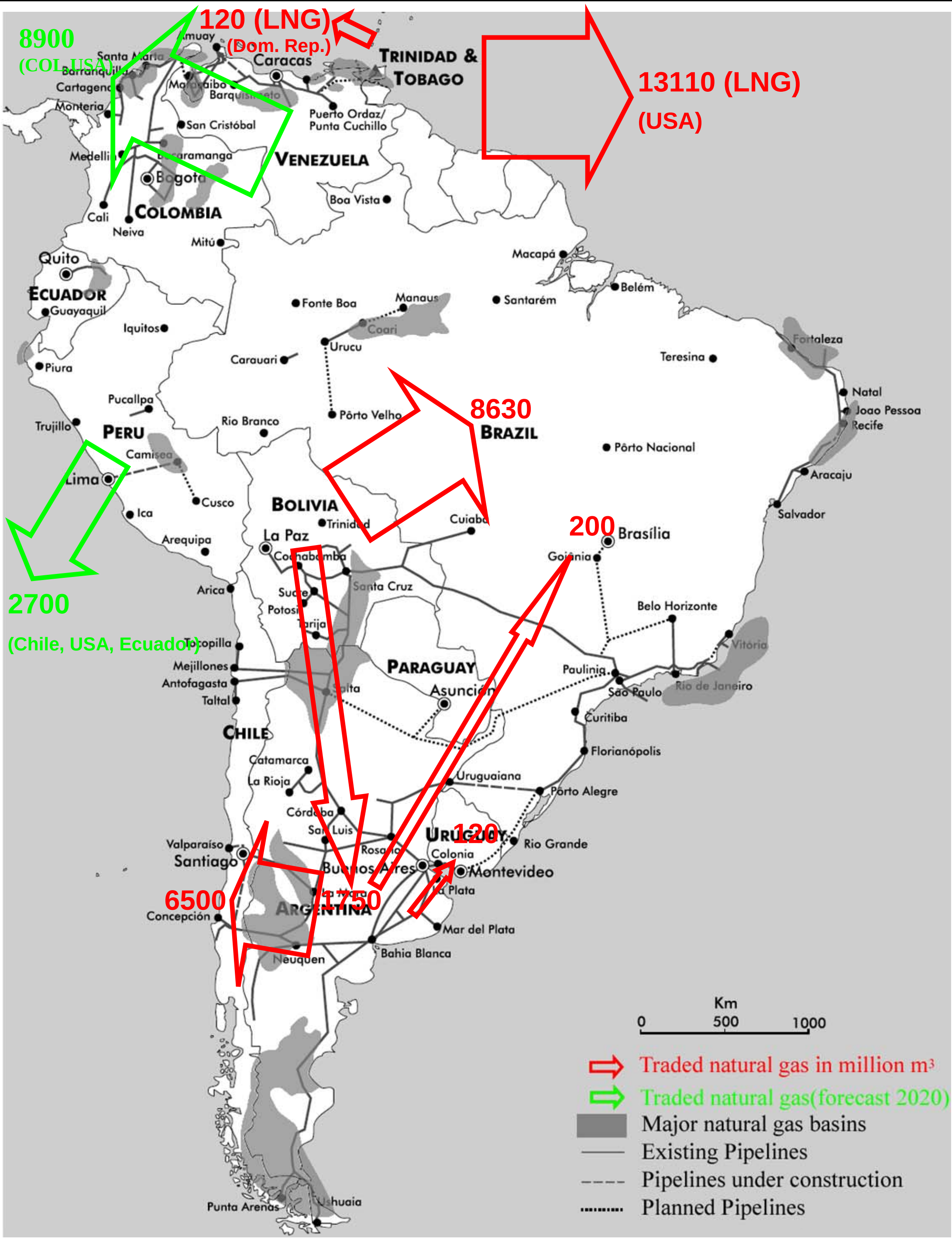
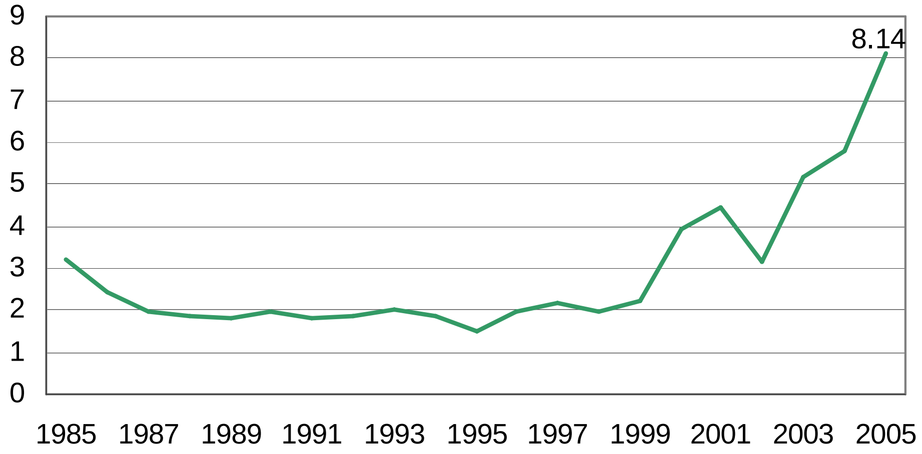
7 Appendix

Figure 9: Major natural gas basins, pipelines and trade flows (in million m^3 as of 2005)



Source: own representation based of IEA (2003 p.241 & 243), BP (2006, p.30), and OLADE/SIEE (2006)

Figure 10: Price of U.S. natural gas imports (dollars per thousand cubic feet)



Source: DOE / EIA (2006d)

Table 3: Basic Questionnaire used for the interviews

1. Major markets for natural gas

- What are the major markets for the natural gas?
- What role plays exportation, to which countries? Future development?

2. Legal Regulation

- How is the measurement of natural gas regulated by law?
  - Production, determination of royalties
  - Type approval and calibration of end-users' meters
  - For Gas Natural Vehicular (GNV)?

3. Industrial Metrology

- What are the major custody transfer points?
- Who measures at these points? Both parties?
- Along the natural gas chain, are there standards in use? How is the compliance verified?
- What equipment is in use (flow meters, orifice plates, calorimeters, chromatographers)?

4. Metrology infrastructure – Capabilities & Requirements

	Reference standards (measuring intervals, traceability, inter-comparison uncertainty)	**Services** (Calibration, Type approval, known uncertainty…)	**Laboratories / Clients** (testing, verification, accreditation.)
Gaseous flow flow high / low pressure			
Calorific content / Composition			
Temperature			
Pressure			
Legal metrology - Pattern approval - initial verification - periodic verification - exceptional verification			

5. What services do (your) customers require?

6. Fields for cooperation

- In what areas of the above mentioned could you provide / need assistance?
- What is your opinion on Latin-American cooperation in this field? (with CENAM / INMETRO)
- What could institutions like PTB, NIST, OAS/SIM contribute?
- How should a possible project preferably be organized/implemented?
- What are specific requirements/conditions for such a project to be successful?

7. Additional comments

8 Excursus: Energy for the Caribbean – The situation in Haiti and the Dominican Republic

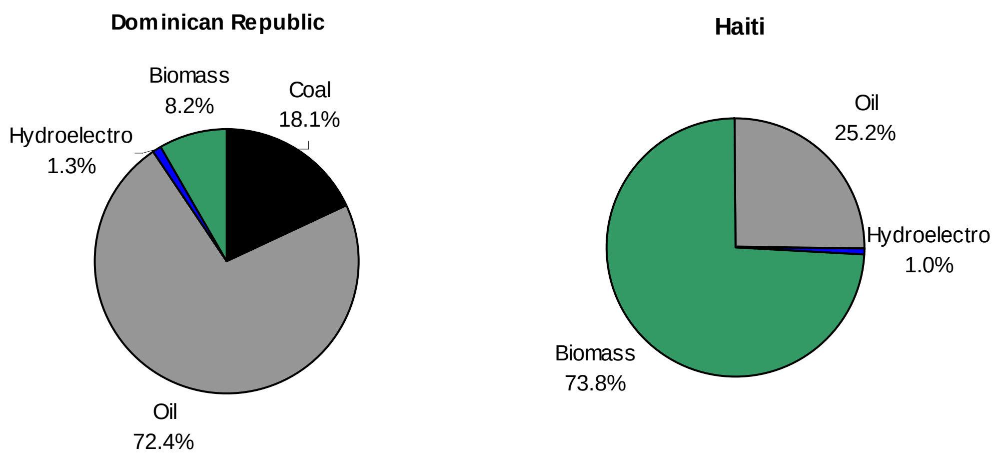
The Caribbean, although not being of relevant size in comparison to South America, exhibits a very different structure of the energy patterns. Fuels reserves are negligible (except for Cuba and Trinidad & Tobago) and hence, the supply depends largely on imports.

This section takes a closer look on the situation in Haiti and the Dominican Republic. Combined, the island of Hispaniola comprises some 12.2 per cent of the Caribbean energy consumption in 2004. However, there are remarkable differences between the two countries: While energy consumption reaches 0.910 tons of oil equivalents (toe) per capita in the Dominican Republic while it is 0.270 toe in Haiti. This difference can be mainly explained by the economic differences expressed by a GDP per capita of 7,000 $ in the former and of 1,700 $ in the latter country.[42]

Basic Indicators on Energy for 2003 (based on IEA 2006)		
Indicator	**Haiti**	**Dominican Republic**
Population (million)	8.44	8.74
GDP (billion 2000 US$)	3.94	21.08
GDP per capita (in US-$) using market exchange rates	467	2412
GDP per capita (in US-$) using purchasing power parities (PPP)	1646	6445
Energy Production (million toe)	1.67	1.55
Energy Imports (million toe)	0.56	6.42
Total Primary Energy Supply (TPES in million toe)	2.24	7.97
Electricity Consumption (TWh)	0.26	9.16
Electricity Consumption per capita (kWh/capita)	30	1048
TPES / Population (toe/capita)	0.27	0.91

42 IEA (2006) and CIA (2006). GDP expressed in PPP-US-Dollar as of 2000 for the year 2005.

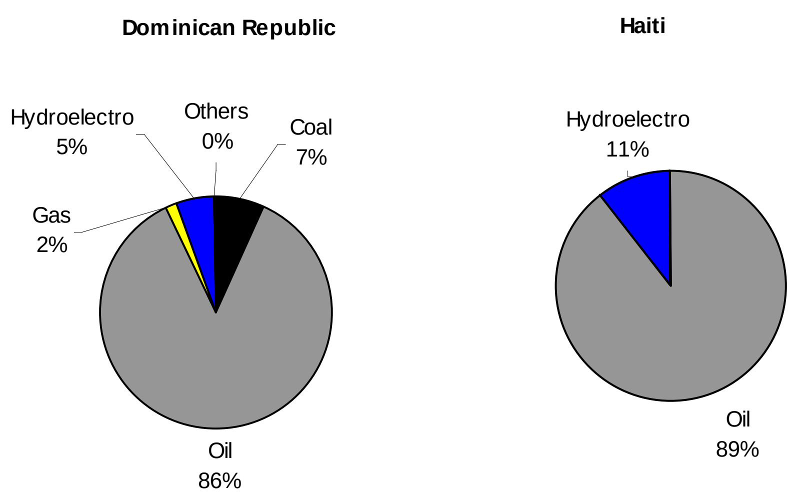
Figure 11: Share of different fuels of the total primary energy supply in 2003



Source: IEA (2006). The figures of DOE / EIA (2006) are somewhat different since they do not include the use of traditional biomass such as fuel wood, which has still an important role especially in developing countries. See also Figure 12.

The biomass is mainly wood and wood coal and is used only for households as primary energy source (87% of the biomass consumption in Haiti). Some 13 per cent of biomass energy there was produced by ‚bagasse', the remaining of sugar cane processing. Bagasse is used by now only used as an energy source for the sugar cane mills.

Figure 12: Share of different fuels of the marketed primary energy supply in 2004



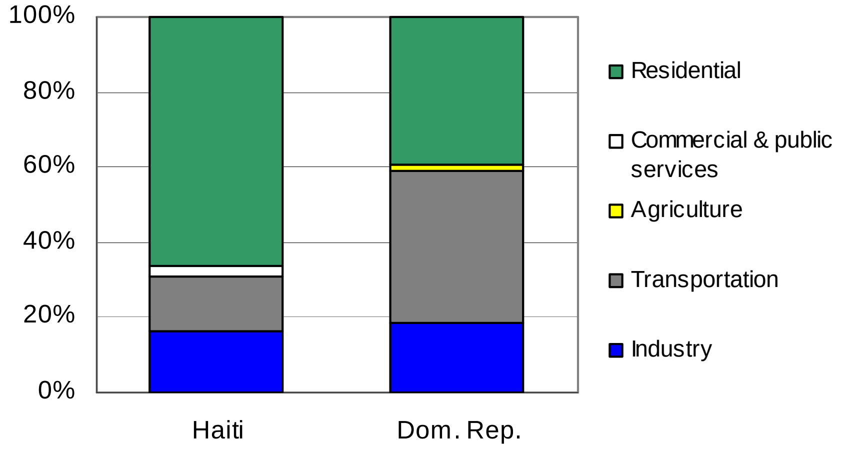
Source: DOE / EIA (2006c). Energy from traditional biomass such as fuel wood is not included.

However, for commercial and industrial purposes, further energy sources have to be discovered. Both countries do not export energy fuels and rely heavily on imports: In

2004, the Haiti and the Dominican Republic had to import 89 % and 94 % of its non-biomass energy respectively.

Particularly, the electrical power generation is highly dependent on imported crude oil (52% in Haiti and 70% in the Dominican Republic). Additionally, the technical infrastructure of distribution of power is still insufficient leading to 32 % and 52 % losses of power in the Dom. Rep. and Haiti respectively.[43] This leads to further shortage of electricity that causes frequent shortages of up to 20 hours.

Figure 13: Sectoral use of primary energy supply (1999)



Source: World Resource Institute (2003)

Given the tremendous rise of crude oil prices, this becomes even more important to ensure the energy supply in the future. Therefore, other domestic alternatives have to be taken into consideration.

Generally speaking, the availability of energy resources depends on four criteria: the geological, technical, and political availability alongside with the availability of adequate means of transportation. Since point resources like coal and other fossil fuels are only of marginal relevance on the island of Hispaniola, the „modern“ renewable energy sources seem to be more promising for the future development. They can be grouped into five categories: wind energy, water power, solar energy, geothermal energy, and bio fuels. The availability of each depends on various reasons and has to be analysed thoroughly.

43 For instance, in Brazil, only 15 per cent and in the United States a mere 9 per cent of total power supply is lost on distribution (IEA 2006).

By now, there have been discussed various sources for Haiti and the Dominican Republic. Firstly, the **biomass** is used already in Haiti by firing the by-products of sugar cane processing (bagasse). However, until now, it is used only for heat generation at the sugar cane mills. But the potential is estimated to be around 37 up to 56 thousand ton oil equivalents (or 5.5 to 8.3 per cent of Haiti's marketed energy consumption in 2004).[44]

Secondly, the Caribbean Islands have been regarded as potential producers of **geothermal energy**. Specifically, the smaller islands that form the active volcanic arc of the Caribe Oriental and the Lesser Antilles have been studied and found promising for the usage of geothermic energy.[45] For the case of Haiti and the Dominican Republic, however, the potential will have to be assessed even though its proximity to the volcanic arc makes potential sources for geothermal energy likely. The German Federal Institute for Geosciences and Natural Resources (BGR) started its GEOTHERM Programme in 2003 supporting partner countries in this field. The assistance provided includes the geoscientific assessment of geothermal resources, regional collaboration, capacity building, and specific training courses.[46] By now, projects in six countries have been realized. The BGR is constantly looking for new cooperation opportunities so that this might be a promising field for a future project. This holds true especially for the Dominican Republic, while the cooperation with Haiti would only be possible in a regional project since Haiti is currently no partner country of the Federal Ministry of Economic Cooperation and Development (BMZ).

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44 Own calculations based on a production of 140,000 tons of bagasse per year. (Sources: DOE / EIA (2006c) and Bureau des Mines et de l'Energie (1999): L'Energie en Haiti: Diagnostic du secteur de l'énergie, online: http://www.rehred-haiti.net/membres/bme/energie/diagnost.html#bilan)

45 See: Huttner, Gerald W., (2000): Geothermal Activity Status in the Volcanic Caribbean Islands, Proceedings World Geothermal Congress 2000, Kyushu - Tohoku, Japan, May 28 - June 10, 2000, online: http://iga.igg.cnr.it/pdf/WGC/2000/R0092.PDF

46 For more information, visit www.bgr.de/geotherm/ or refer to Katrin Kessels (katrin.kessels@bgr.de)