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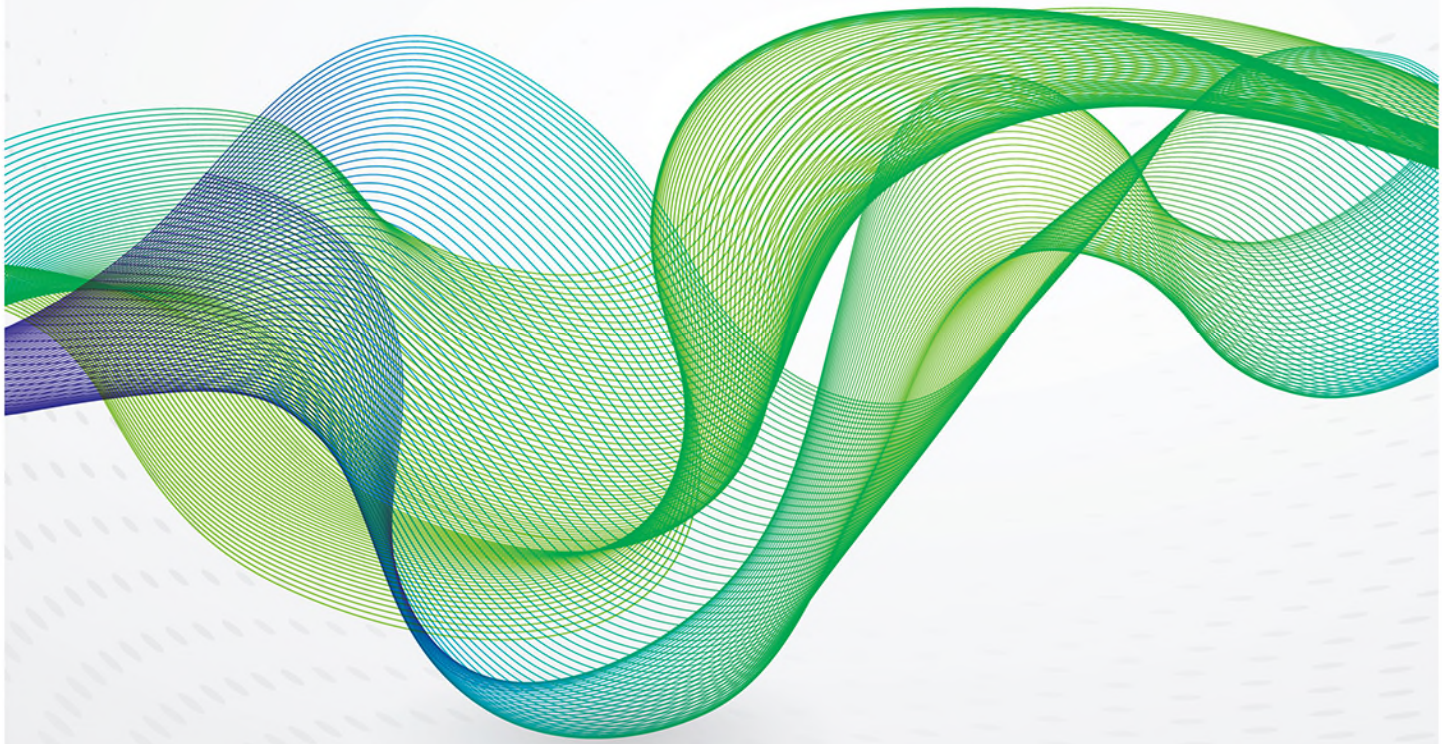
Unconventional Gas in Argentina:
Will it become a Game Changer?



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Ieda Gomes & Roberto Brandt

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Preface

Prior to the dramatic reduction in regional gas reference prices and global oil prices in 2014, Argentina was viewed as one of the key 'next best bets' for successful shale gas development after the remarkable success of shale gas in the US. Despite the handicap of a deteriorated upstream investment framework under the Kirchner administration - hopes were rekindled for a more IOC-friendly environment under President Mauricio Macri.

Argentina clearly has a world-class shale gas resource and its 'crown jewel' is the Vaca Muerta play. How such a resource might be developed and link to global gas trade flows in terms, for example, in reducing Argentina's LNG import requirements is a complex multi-vector issue. This paper by Ieda Gomes and Roberto Brandt provides a comprehensive analysis of Argentina's gas prospects based on a deep contextual understanding of the country's hydrocarbon history, the changing regulatory and political framework of oil and gas production and its changing attractiveness, or otherwise, for IOC investment, and the outlook for the future.

Regional gas prices prevailing in 2016 are generally below the levels required to bring on major new tranches of gas supply in a global sense. It is not surprising then that upstream activity in unconventional gas in Argentina is currently subdued. As the market rebalances over the next five to ten years, this paper provides the insight into how Argentina's upstream gas industry might respond.

The OIES Gas Programme has a keen interest in understanding all the main moving parts on the demand and supply side of the global gas system as this informs not only the likely regional and global price formation evolutionary dynamics but also the resulting geo-political impacts. I am grateful to the authors of this paper for providing such a comprehensive assessment of Argentina's upstream conventional and unconventional potential and the likely role it will play in the global system.

Howard Rogers

Oxford

September 2016

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About the Authors

Ieda Gomes is a Senior Visiting Research Fellow at the Oxford Institute for Energy Studies. Her areas of expertise include natural gas and LNG market fundamentals as well as energy pricing, policy and regulation, particularly in developing countries in South Asia, the Middle East, Africa and Latin America. Ieda's career in the gas and energy industry spans more than 30 years. She worked for nearly 14 years at BP plc as Vice President for new ventures and market development on several international assignments and for 19 years at the largest gas distribution company in Brazil, Comgas. She has been a key participant and shaper of events in Brazil's gas industry - from the introduction of natural gas supplies in Sao Paulo to the negotiation and signature of the domestic and Bolivian gas supply agreements, the privatisation of Comgas and the establishment of the Brazilian Association of Gas Distribution Companies (ABEGAS). Ieda is based in the UK and sits on the boards and advisory councils of several companies and associations. She writes a bimonthly column for Brazil Energia and is a senior adviser of the Brazilian think tank FGV Energia. Ieda holds a BSc in Chemical Engineering (University of Bahia, Brazil) and MSc's in Energy (University of São Paulo, Brazil) and Environmental Engineering (Polytechnic School of Lausanne, Switzerland).

Roberto Brandt is a senior international energy consultant, with 38 years of experience in corporate, public policy, consulting and academic activities. From 2000 to 2009 he acted as senior executive of BG Group, with responsibilities in Argentina (as CEO of MetroGAS, the largest gas distribution company of South America), Uruguay (as CEO of Gasoducto Cruz del Sur) and the United Kingdom (as member of the Strategy team). Between 1988 and 2000, he was fully devoted to energy consulting - with special focus on oil and gas in Latin America -, as President of Ecoenergía (first) and Mercados Energéticos (later). From 1978 to 1988, Roberto performed as Advisor to the Energy Secretary of Argentina - among other tasks, as Project Director of the 1986/2000 National Energy Plan - and as Head of the Pricing Division and Commercial Planning economist of YPF (the Argentine National Oil Company). Roberto has an extensive record of accomplishment in international energy organisations, including the International Gas Union (IGU), the World Energy Council (WEC), the World Petroleum Council (WPC) and the Latin American Energy Organization (OLADE). He holds a BSc degree in Economics (University of Buenos Aires, Argentina) and an MSc (DEA) in Energy Economics (University of Grenoble, France).

Units

Arg $	=	Argentine pesos
Bbl	=	Barrels of oil
Bcf	=	Billion cubic feet
Bcf/d	=	Billion cubic feet per day
Bcm	=	Billion cubic metres
Bcma	=	Billion cubic metres per annum
boe	=	Barrels of oil equivalent
Boe/d	=	Barrels of oil equivalent per day
Btu	=	British Thermal Units
GJ	=	Gigajoule
GW	=	Gigawatt
GWh	=	Gigawatt hour
m^3	=	Cubic metres
m^3/d	=	Cubic metres per day
MMBtu	=	Million British Thermal Units
MMcf	=	Million cubic feet
MMcf/d	=	Million cubic feet per day
MMm^3/d	=	Million cubic metres per day
MTPA	=	Million tonnes per annum
MW	=	Megawatt
MWh	=	Megawatt hour
Tcf	=	Trillion cubic feet
Tcm	=	Trillion cubic metres
toe	=	Tonnes of oil equivalent
Tonnes	=	Metric tonnes
USD	=	US dollars

Conversion factors utilised

1GJ = 0.94781712 MMBtu

1 cubic feet = 0.02832 cubic metres

1Tcf = 28.32 x 10^9 m^3 of natural gas

10^9 m^3 of natural gas = 35.351 Bcf

Glossary

ADIGAS	Argentine Gas Distributors' Association
ARI	Advanced Resources International
ASAP	Asociación Argentina de Presupuesto y Administración Financiera Pública (Argentine Association of Budgeting and Public Finance Administration)
Brent	Brent crude oil - Benchmark for international pricing
CAF	Corporación Andina de Fomento
CAGR	Compound Annual Growth Rate
CAMMESA	Compañía Administradora del Mercado Mayorista Eléctrico (Argentine Wholesale Electricity Market Dispatch Operator)
CAPEX	Capital Expenditure
CIA	US Central Intelligence Agency
CIF	Cost, Insurance and Freight
CNG	Compressed Natural Gas
DCQ	Daily Contracted Quantity
DES	Delivered Ex-Ship
DOE	US Department of Energy
EIA	US Energy Information Administration
ENAP	Empresa Nacional de Petróleo de Chile (Chilean National Oil Company)
ENARGAS	Ente Nacional Regulador del Gas (National Gas Regulatory Board)
ENARSA	Energía Argentina S.A. (Argentine State-owned Energy Company)
FOB	Free on Board
GDP	Gross Domestic Product
GNF	Gas Natural Fenosa
HH	Henry Hub (US Natural Gas Reference Price)
IAPG	Instituto Argentino del Petróleo y el Gas (Argentine Institute of Oil and Gas)
IMF	International Monetary Fund
INDEC	Instituto Nacional de Estadísticas y Censos (Argentine National Institute of Statistics)
LNG	Liquefied Natural Gas
LPG	Liquefied (or liquid) Petroleum Gas
MAyDS	Ministerio de Ambiente y Desarrollo Sustentable (Argentine Ministry of Environment and Sustainable Development)
MEG	Mercado Electrónico del Gas (Argentine Electronic Gas Market).
MME	Ministerio de Minas e Energia (Brazilian Ministry of Mines and Energy)
MEyM	Ministerio de Energía y Minería (Argentine Ministry of Energy and Mines)
NGLs	Natural Gas Liquids
NGO	Non-Governmental Organisation
OPEX	Operational Expenditure
RLI	Reserves Life Index
Proppant	Sand or man-made materials designed to keep hydraulic fractures
TELAM	Argentine News Agency
TGN	North Gas Transmission Company
TGS	South Gas Transmission Company
USA	United States of America
VAT	Value-added tax
WTI	West Texas Intermediate crude oil – Benchmark for international pricing
YPF	YPF (Argentina), formerly Yacimientos Petrolíferos Fiscales
YPFB	Yacimientos Petrolíferos Fiscales Bolivianos

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1. Introduction

Argentina is the largest gas consuming country in South America, with an established oil and gas industry spanning over a century. Natural gas supplies 51% of the country's energy requirements.

In 2015 gas consumption reached 1.7 Tcf (47.5 Bcm)[1], largely exceeding the demand levels of Brazil, Spain or France. Argentina possesses a very comprehensive pipeline infrastructure and a highly developed and mature internal market: natural gas is extensively used for residential, commercial, transport, industrial and power generation purposes. Domestic gas supply, that attained 1.3 Tcf (36.5 Bcm)[2] in 2015, is insufficient to meet the country's needs.

Until the mid-2000s, Argentina generated significant surplus natural gas production, exported by 11 international pipelines to Chile, Uruguay and Brazil. However, the public policies that prevailed at the outcome of the 2001/2002 economic crisis - characterised by increasing governmental interventionism, "artificial" energy pricing and widespread subsidies - eventually led to a sharp decline in domestic (oil and) gas reserves and production, and transformed the country into a net gas and hydrocarbons importer - respectively - in 2008 and 2011. Natural gas, Liquefied Natural Gas (LNG), diesel and fuel oil constitute the bulk of these imports, which are largely destined to meet power generation needs. This structural fuel trade deficit has caused significant fiscal costs and macroeconomic impacts, including a recurrent erosion of the country's foreign currency reserves.

As mentioned, one of the main causes of this demand/supply imbalance has been "artificial" pricing. Natural gas prices to producers and final consumers have been set at discretionary levels for over a decade, within a regulatory philosophy known as "pricing segmentation", that combines ad-hoc quotation differentiations by basins, end-users and "pre-existing" or (more recently) "new" gas with the extensive use of subsidies and the decoupling of domestic and international markets.

After a decade of declining conventional production, the discovery and/or increasing awareness of significant unconventional oil and gas resource potential - especially, tight-sands gas and shale, mostly located in the Neuquén basin -, coupled with government incentivised producer prices, has led to considerable interest in the area. According to a US Energy Information Administration (EIA) worldwide shale study, Argentina possesses world-class shale oil and gas resources, estimated at 27 billion barrels of risked shale oil (also known as tight oil) and 802 Tcf of risked shale gas in place, making it the second largest shale gas holder worldwide.

The most promising formation is Vaca Muerta ("Dead Cow"), located in the Neuquén basin, which has shale strata with a thickness of 250-300 metres in some places. Another important lever is that Vaca Muerta is located in a region with a significant oil and gas exploration and production history, which facilitates local community and political acceptance. There are currently at least 15 ongoing shale pilots and early-stage commercial production projects in Neuquén, led by the state-controlled company YPF, in partnership with Chevron and - at a smaller scale - with Dow and Petronas. Total, ExxonMobil, Shell and several smaller local and international companies are also very active. In 2015, YPF signed joint-venture agreements with Sinopec and Gazprom, which are yet to produce results.

Activity in Vaca Muerta started in 2009, and the first unconventional oil and gas discoveries took place in 2010. The Loma Campana project, operated by YPF in partnership with Chevron, has shown an impressive activity set, with production reaching 50,600 boe/d in December 2015 - comprising 36,200 Bbl/d of oil and 2.4 MMm^3/d of natural gas. By mid-2016 more than 600 wells had been drilled in Loma Campana and other Vaca Muerta concession areas. The initial focus was on oil prone areas

[1] Figures do not include gas industry's own consumption and system losses.
[2] Net production, which excludes gas flaring and recycling.

and vertical drilling, but more recently YPF and its partners are shifting to more productive - and more expensive - horizontal drilling.

Unconventional gas production reached 235.5 Bcf (6.7 Bcm) in 2015, accounting for 15.5% of Argentina's total gas production. Almost 73% of these volumes originated in tight-sands gas fields - some of which started operating in 2009 -, whose production is much larger than shale gas.

By year-end 2015, the cumulative number of completed unconventional gas and oil wells in Argentina reached 1,101, of which 673 are shale (gas and oil) and 428 are tight-sands wells. In 2015 alone the operators drilled 376 new wells, of which 218 were shale and 158 were tight-sands wells.

The accumulated investment in unconventional oil and gas exploration and production in the 2012/2015 period totalled USD 9.3 billion, of which 18% (USD 1.7 billion) corresponds to exploration activities. Neuquén accounted for most of the investment, circa USD 8.9 billion.

At the international oil and gas prices prevailing in 2016, and despite the fact that domestic prices are temporarily decoupled and set at higher levels, the expansion of Argentina's unconventional gas production in the short term will mostly come from tight-sands gas. Also new investment in shale will be kept at a minimum, in a context in which most international companies have sharply reduced CAPEX levels and are following a "wait and see" approach.

Six main pillars underpinned the US shale gas revolution: a favourable fiscal regime, knowledge of the subsurface, investment in research and technology, a full range of upstream players, political support and public acceptance.

Taking into account the significant unconventional gas resources in Argentina or, in other terms, a relatively favourable "below surface" starting point, **this research paper will mostly focus on the following topics**: (i) a detailed characterisation and 2016/2030 outlook of the Argentine gas market; (ii) a description of the current status and prospects of the country's unconventional gas development; (iii) the identification of the key "above surface" challenges to be faced at a national and local level; and (iv) a comparison of the fundamentals of Argentina's gas industry with the key enablers and success factors in the USA, with a view to determine if unconventional gas could also become a "game changer" at the other end of the Americas.

2. Brief country and energy sector overview

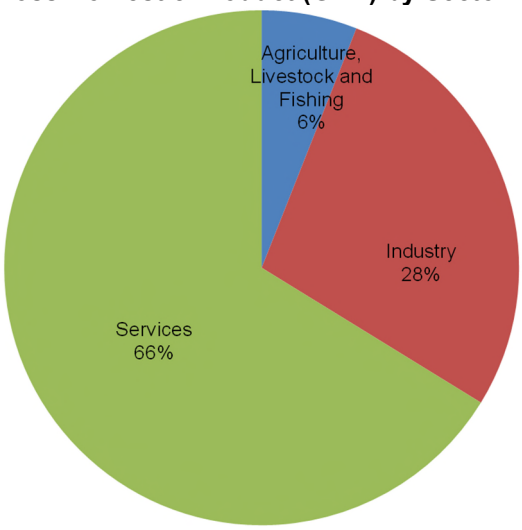
2.1 Country overview

The Republic of Argentina (República Argentina) is the second largest economy in South America, with a population in excess of 43 million inhabitants spread over 23 provinces and an autonomous city - Buenos Aires. Argentina is also the second largest country in South America, with a continental surface of 2,780,400 km^2, second only to Brazil. Argentina is strategically located in the Southern Cone of South America, between the South Atlantic and the South Pacific oceans, which allows for the control of vital trade routes in the southern hemisphere (Strait of Magellan, Beagle Channel, and the Drake Passage).

According to the International Monetary Fund (IMF), Argentina's GDP in 2014 was USD 544.7 billion[3]. Argentina's economy relies significantly on its natural resources, even though its industrial sector is well developed. The country is a significant food producer, ranking among the world's largest beef and soybean exporters and is a leading producer of sunflower seeds, yerba mate (an infusion that resembles tea), lemons and soybean oil.

According to the Argentine National Institute of Statistics (INDEC)[4], agriculture and industry jointly contribute approximately one third of Argentina's GDP, while the remaining two thirds originates in the service sector, that has consistently expanded during the last decades (Figure 2.1.1).

Figure 2.1.1 Argentina: Gross Domestic Product (GDP) by Sector – 2015



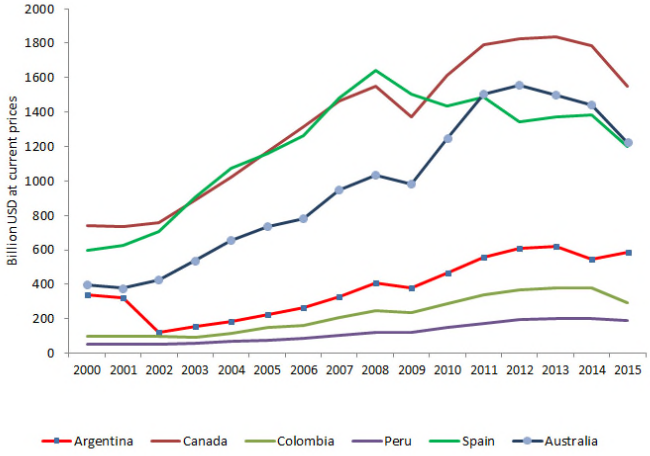
Source: Based on information from the National Institute of Statistics (INDEC).

Argentina stands among the 50 largest economies in the world. In comparison with other countries with population ranging between 30 and 60 million inhabitants, Argentina is a mid-sized economy whose fundamentals have been challenged at the beginning of the 21st century (especially in 2001/2002), but was not strongly affected by the 2008/2009 economic crisis, in contrast to what occurred in developed economies.

[3] (IMF, 2016)
[4] Throughout this paper, extensive reference will be made to INDEC statistics, For further information see http://www.indec.gov.ar/

It is interesting to compare the trajectory of Argentina's economic growth with Australia's, which is also a heavily commodity-dependent country (Figure 2.1.2). In addition to the boost of the commodity boom, Australia's GDP has benefited from diversification towards households spending, construction and large infrastructure projects.

Figure 2.1.2 Argentina / Selected Countries: Comparative GDP Evolution – 2000/2015

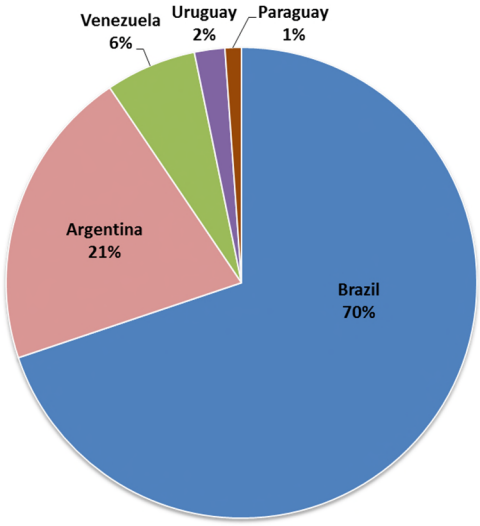


Source: World Economic Outlook Database - International Monetary Fund (IMF).

According to the Central Bank of Argentina, Argentina was relatively spared from the 2008/2009 world crisis due to the implementation of countercyclical policies which generated liquidity buffers in local and foreign currencies, coupled to a managed floating exchange regime and control of capital movements (Central Bank of Argentina, 2010). Also Argentina's largest export markets – China and Brazil - were not heavily impacted by the financial crisis.

Argentina is an active member of the Mercosur trade zone and, according to the IMF, in 2014 the country accounted for 21% of the Mercosur GDP (Figure 2.1.3).

Figure 2.1.3 Argentina: Share of Mercosur Trade Zone - 2014

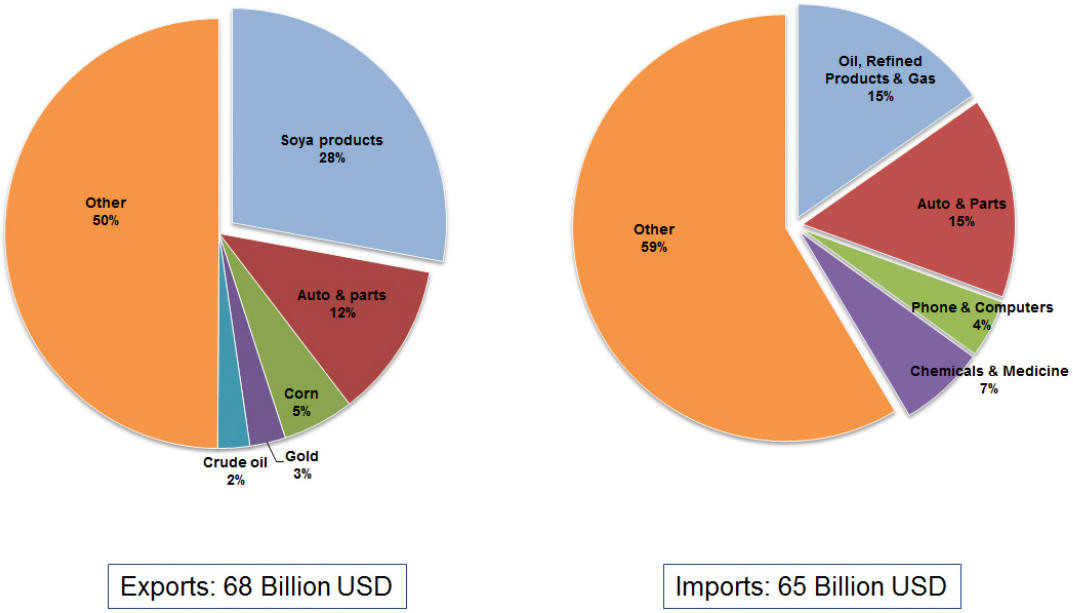


Source: World Economic Outlook Database - International Monetary Fund (IMF).

Despite the economic crisis of 2001/2002 - when the government decided to unpeg the national currency (Argentine Peso) from the US dollar -, Argentina subsequently benefited from the increase in commodities prices and followed governmental redistributive policies that boosted consumption among the lower income tranches of the population. Consequently, the growth in GDP averaged 6.5% in the 2003/2013 period[5].

In 2014 Argentina imported USD 65 billion in goods and services (Figure 2.1.4). Argentina's top imports are vehicles and auto-parts, liquid fuels/natural gas and communication/computer equipment. Oil by-products and natural gas accounted for 15% of Argentina's total imports. Argentina's top exports are commodities and agriculture – taken together, with a significant contribution from soya products[6]. (Note: Both in imports and exports, the category "Other" encompasses hundreds of products.)

Figure 2.1.4 Argentina: Top Imports and Exports – 2014 (Billion USD)



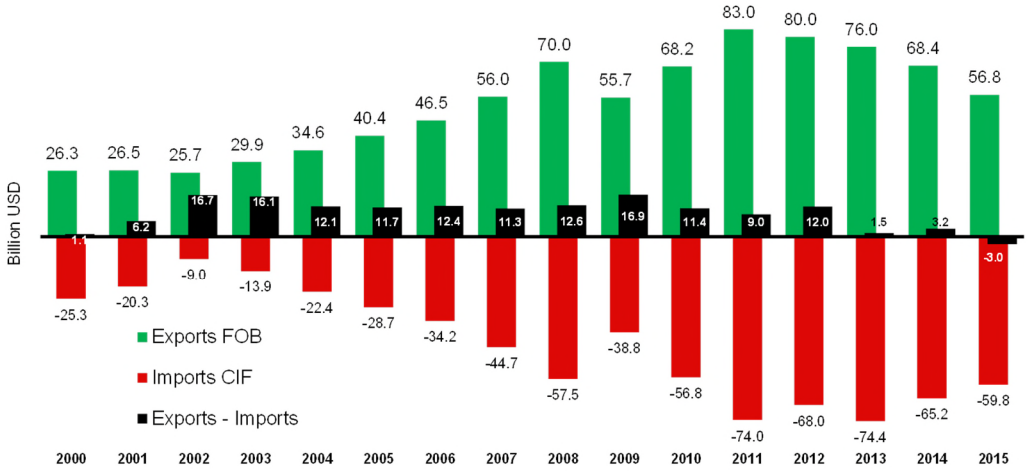
Source: Atlas Media, Massachusetts Institute of Technology (MIT)

Until 2012 Argentina maintained a healthy trade surplus, a situation which deteriorated considerably in 2015 (Figure 2.1.5), mostly as a consequence of the growing imports of liquid fuels, pipeline natural gas and Liquefied Natural Gas (LNG). Argentina was a net hydrocarbons exporter until 2010. The situation flipped as a result of the public policies that prevailed at the outcome of the 2001/2002 economic crisis, characterised by increasing governmental interventionism, "artificial" energy pricing (especially for gas and electricity) and widespread subsidies (both on the demand and supply sides), which eventually led to a sharp decline in domestic oil and gas production, and significant fiscal costs and macroeconomic impacts.

[5] According to the IMF, alternative data sources have showed significant lower real growth than the official figures since 2008 (IMF, 2016). In June 2016, INDEC published revised 2004/2015 series which confirmed this, by lowering the current GDP level by approximately 15%. SHOULD THIS BE "BY 15%"?

[6] For further information, see http://atlas.media.mit.edu/en/profile/country/arg

Figure 2.1.5 Argentina: Foreign Trade - 2000/2015 (Billion USD)

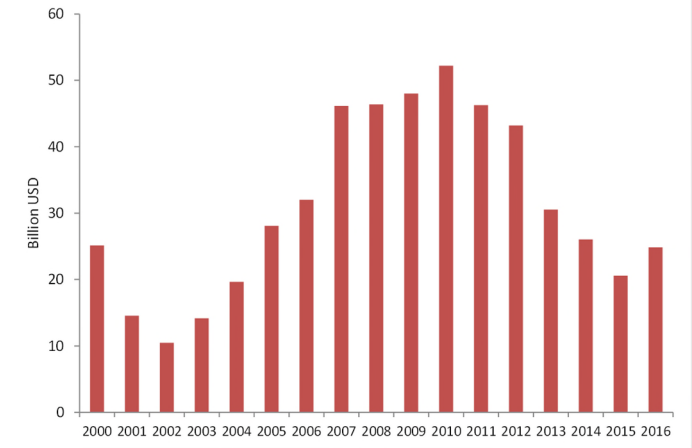


Source: Based on information from the National Institute of Statistics (INDEC).

Indeed, the lack of attractive economic signals - especially during the 2003/2015 period, under the presidencies of Néstor Kirchner (2003/2007) and Cristina Fernandez de Kirchner (2007/2015) - caused a significant reduction in exploration and production investment, whilst demand increased, buoyed by low end-user prices - against the background of imported oil and gas prices starting to rise significantly. As a result, Argentina's energy imports have been on the rise over the last 10 years, led by gas/LNG, which represents 51% of the country's energy requirements. Argentina has gone from exporting 20 MMm^3/d (258 Bcf) of natural gas in 2004 to importing approximately 35 and 30 MMm^3/d (444 and 379 Bcf) - respectively - in 2014 and 2015. (For further detail, see Sections 3.3 and 3.4.)

According to the IMF, the impact of Argentina's negative energy trade balance accounted for a deficit of 1% of the country's GDP in 2014, compared to a surplus of 2% in 2007. Energy imports have also placed a heavy burden on Argentina's foreign currency reserves, which dropped from USD 53 billion in 2011 to USD 26 billion in January 2016 (Figure 2.1.6)[7].

Figure 2.1.6 Argentina: Foreign Currency Reserves (1) – 2000/2016 (Billion USD)



Reference: (1) 2016 refers to May 2016.
Source: Based on information from Trading Economics and the Global Economy.

[7] For further information see http://www.tradingeconomics.com/argentina/foreign-exchange-reserves and http://www.theglobaleconomy.com/Argentina/Reserves/

According to the IMF, Argentina's economy is expected to contract by 1% in 2016 and to grow by 2.8% in 2017.

The 2014/2015 period saw a rapid deterioration of Argentina's economy, as a result of the lack of access to international capital markets, in the wake of the 2014 decision of the US Supreme Court upholding the judgement of the Appeal Court of New York in favour of holdout funds which did not adhere to the renegotiation of Argentina's bonds. Foreign investors also lost confidence in the country due to increasing governmental interventionism - and several nationalisation initiatives - in virtually all sectors of the economy. The economic slowdown of Argentina's key export markets - China and Brazil - also significantly reduced the export revenues from commodities, semi-industrialised goods and the automotive industry.

Following the inauguration of President Mauricio Macri, in December 2015, the incoming government immediately abolished stringent currency controls and eased the rules allowing for the remittance of dividends abroad. President Macri has vowed to promote economic reforms aiming at regaining foreign investor confidence, in particular in the energy sector.

In April 2016, in the wake of a deal agreed with the country's lenders, Argentina returned to the bond market by selling USD 16.5 billion of sovereign debt. A substantial part of the proceeds will be used to pay the creditors of the 2002 default[8]. The Argentine provinces are also planning to issue around USD 30 billion in the international bond market.

The incoming administration has also announced plans to invest USD 2 billion in infrastructure, partially funded by the multilateral agency Corporación Andina de Fomento (CAF).

As a result of the new government actions and plans there is renewed interest from foreign investors in exploring potential business opportunities in Argentina, although there is widespread consensus that the transition process towards a more market-oriented economy will inevitably be challenging and complex.

2.2 Energy sector overview

Oil and gas play a key role in Argentina's National Energy Balance[9]. Figure 2.2.1 shows that the contribution of hydrocarbons has surpassed 85% of the total energy supply from 1980 to 2014.

During that period, natural gas steadily increased its share - from 27% in 1980 to 51% in 2014 -, displacing oil as the predominant source of energy. In sharp contrast with Brazil and other Latin American countries, hydroelectricity only represents slightly over 5% of energy supplies, even though Argentina possesses important hydro resources. Nuclear and coal both contribute approximately 2%, and renewable sources - mostly, biomass and biofuels - play a marginal role, despite the country's significant potential, especially in wind and solar energy.

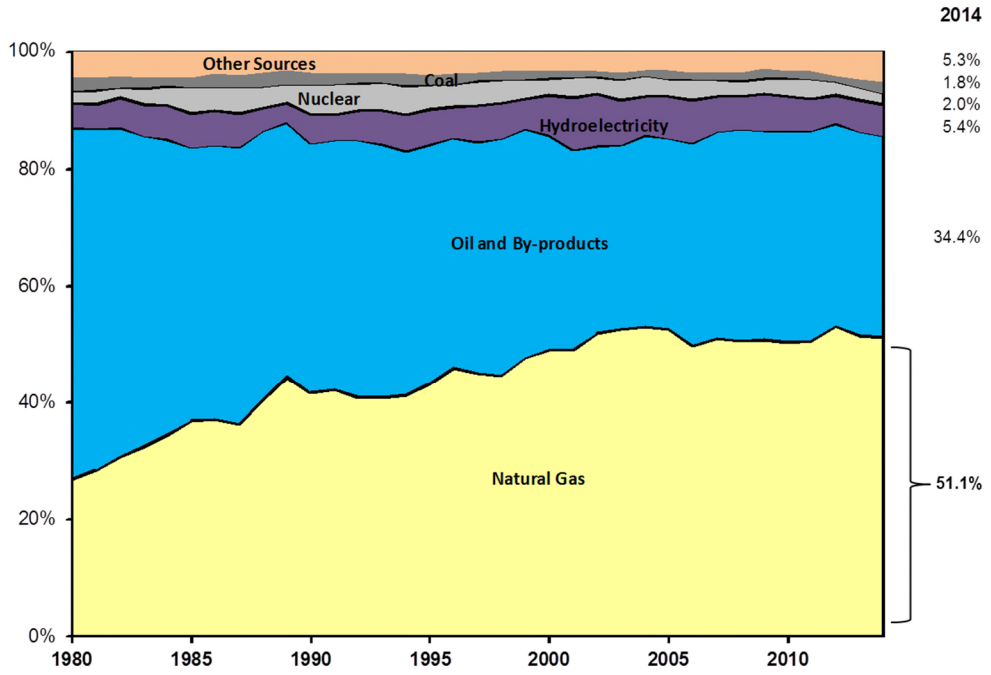
In terms of natural gas' contribution to total energy requirements (i.e., what is widely referred to as "consumption by fuel"), Figure 2.2.2 illustrates that Argentina ranks high amongst the largest national or regional markets. According to the "BP Statistical Review of World Energy 2016", in 2015 Argentina's share was comparable to that recorded in Russia, Egypt and Pakistan[10].

[8] http://www.bbc.co.uk/news/business-36078729

[9] Throughout this paper, extensive reference will be made to statistics of the Argentine Ministry of Energy and Mines (MEyM) and the National Energy Balances, For further information see https://www.minem.gob.ar/index.html

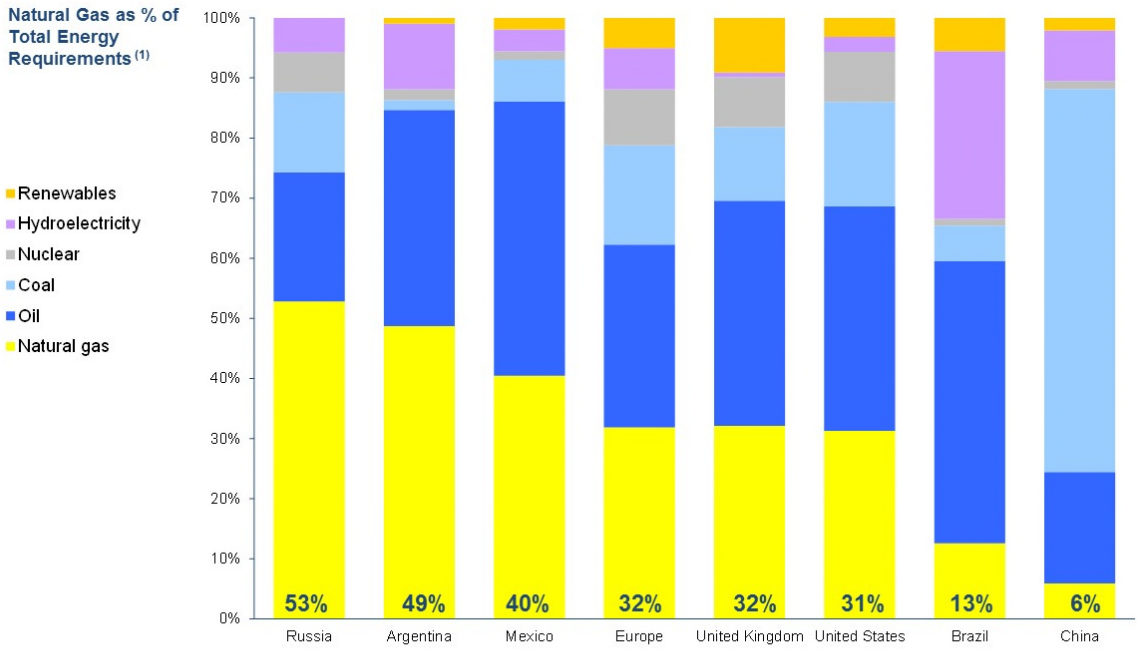
[10] (BP, 2016). In 2015, Argentina ranked 14th in the world in terms of gas market coverage of the energy matrix. However, most of the countries with higher values - ranging from 91 to 64% - are smaller scale markets, such as Trinidad & Tobago (ranking 1st) of Eastern Europe, Middle East, Asia Pacific and the North of Africa.

Figure 2.2.1 Argentina: Natural Gas Contribution to the National Energy Balance - 1980/2014 (% of total energy supply1)



Reference: (1) Total energy supply = Primary energy internal supply + Secondary energy imports - exports
Source: Based on information from the Argentine National Energy Balances.

Figure 2.2.2 Argentina / Selected Countries: Gas Contribution to the National Energy Balance - 2015

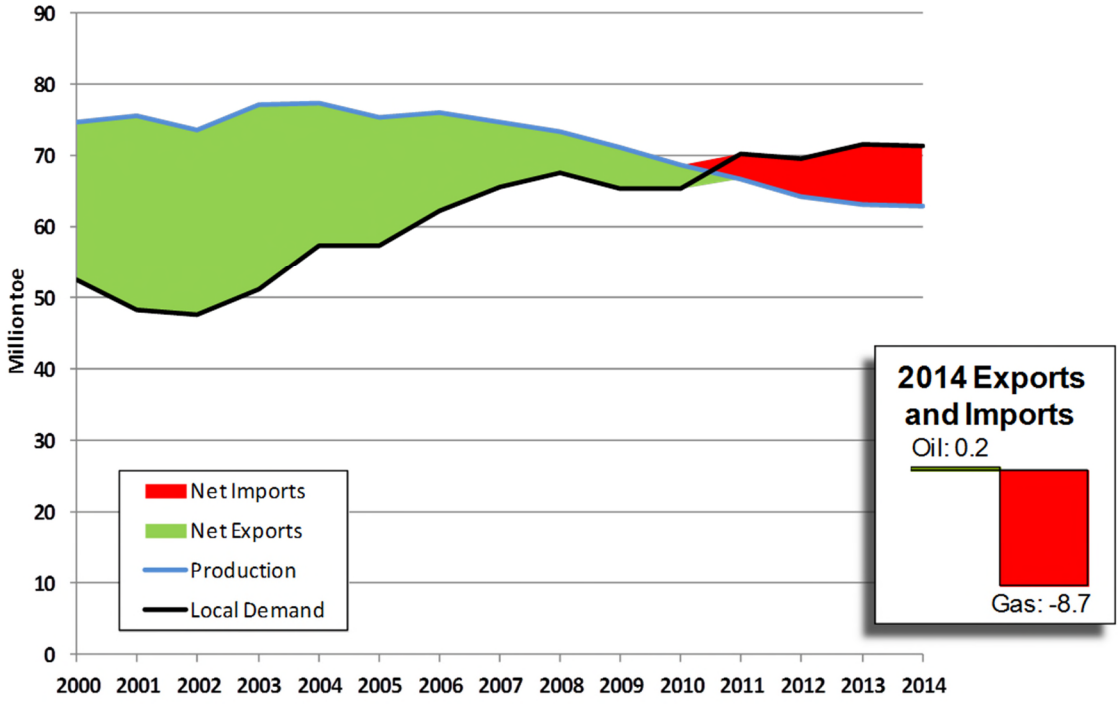


Reference: (1) Corresponds to BP's "Consumption by Fuel", used for international comparison purposes. Argentina's last official Energy Balance was published in 2014, and gas contribution amounts to 51%.
Source: Based on information from BP Statistical Review of World Energy 2016.

Though Argentina's gas industry dates back to the 1950s, its most dynamic expansion originated in the discovery of the giant field of Loma La Lata in the Province of Neuquén, at the end of the 1970s, and the ensuing duplication of the country's natural gas reserves. That process led to a significant expansion of the trunk gas pipeline capacity; an increasing penetration in the residential market; the development of Compressed Natural Gas (CNG) for vehicles; the replacement – by gas - of most liquid fuels consumed in the industrial sector; the commissioning of a large number of gas-fired combined cycle power-plants; and even the construction of eleven export pipelines to Chile, Brazil and Uruguay. Low and subsidised prices for natural gas - adopted from 2002 onwards - also helped to enhance this trend.

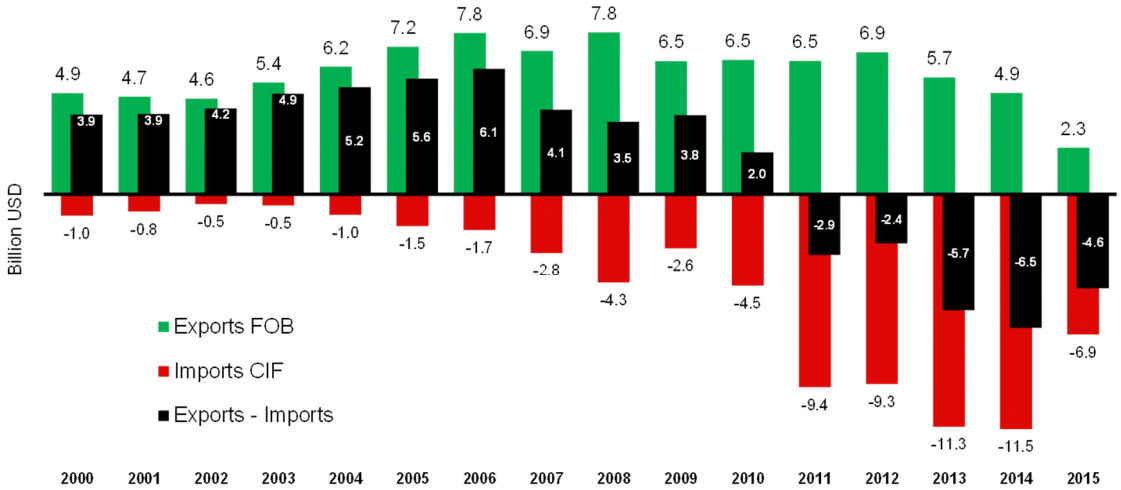
However, these "artificial pricing" policies led to a strong decline in domestic gas production as of 2004, which - in conjunction with a consistent fall in oil extraction - turned the country into a net hydrocarbons importer from 2011 onwards, as can be seen in Figures 2.2.3 and 2.2.4. Argentina's fuel exports were higher than imports between 2000 and 2010, originating a cumulative surplus of over USD 60 billion. However since 2011 Argentina's imports continuously exceeded exports, with annual deficits ranging from 4.6 to 6.5 billion USD between 2013 and 2015, resulting in highly negative impacts on the country's commercial balance and economy.

Figure 2.2.3 Argentina: Production and Consumption of Hydrocarbons – 2000/2014 (10^6 toe)



Reference: "Oil" includes by-products (ie, gasoline, jet fuel, LPG, diesel oil and fuel oil).
Source: Based on information from the Argentine National Energy Balances.

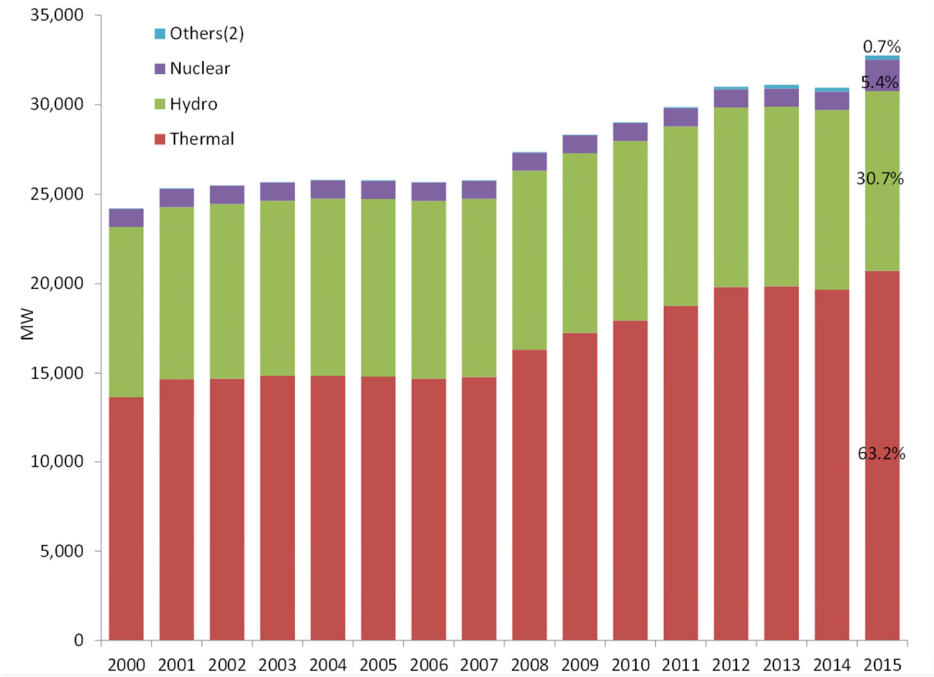
Figure 2.2.4 Argentina: Fuels Exports and Imports (1) – 2000/2015 (Billion USD)



Reference: (1) Includes oil and by-products (mainly gasoline, jet fuel, diesel oil and fuel oil), biodiesel, natural gas, LNG and coal.
Source: Based on information from the National Institute of Statistics (INDEC).

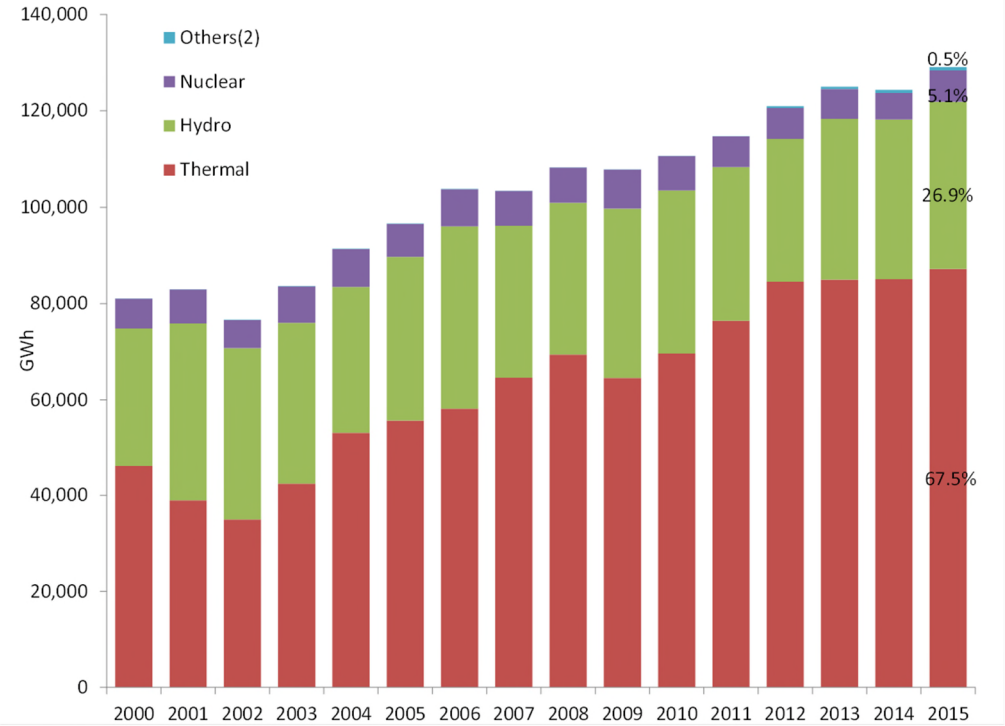
Figures 2.2.5 and 2.2.6 reflect the significant expansion of thermal power capacity and generation experienced during the 2000/2015 period, precisely due to the increasing use of natural gas. In 2015 thermal power accounted for 63% of the installed capacity, and over 67% of the electricity generation, of Argentina.

Figure 2.2.5 Argentina: Power Capacity (1) – 2000/2015 (MW)



References: (1) Includes Interconnected and Isolated Systems. Excludes self-production.
(2) Others: Includes wind, solar and others.
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Figure 2.2.6 Argentina: Power Generation (1) – 2000/2015 (GWh)



References: (1) Includes Interconnected and Isolated Systems. Excludes self-production.
(2) Others: Includes wind, solar and others.
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

3. Characterisation of Argentina's natural gas market

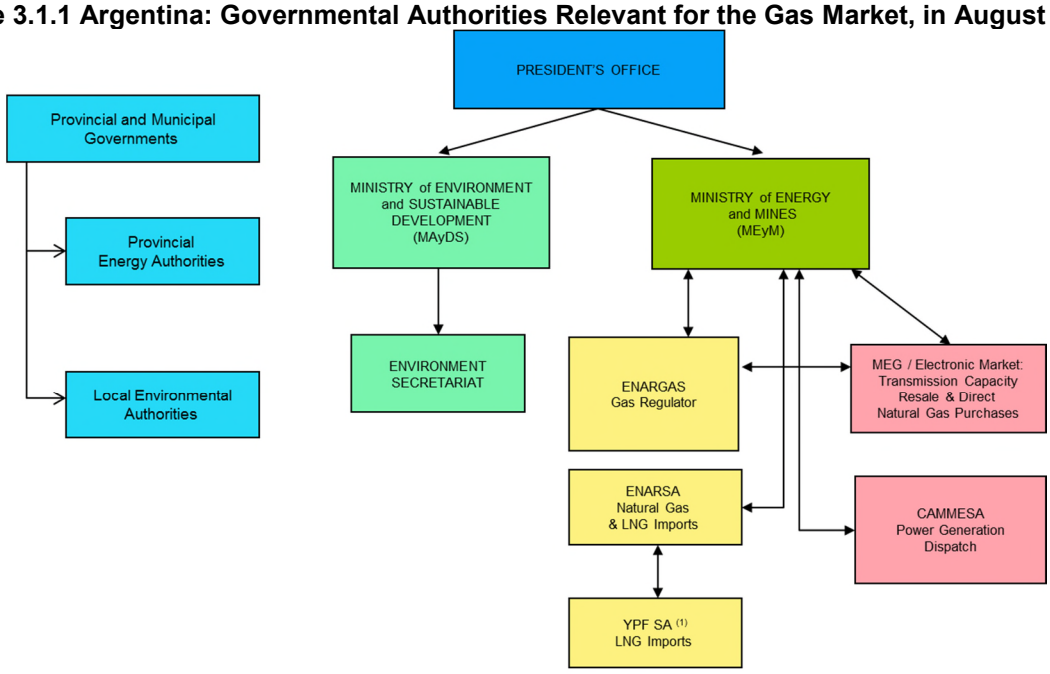
3.1 Institutional framework, industry structure and relevant players

Figure 3.1.1 illustrates the role of - and interaction between - the key governmental authorities that regulate the activities of the natural gas market in Argentina.

The Ministry of Energy and Mines (MEyM) regulates the exploration and production of fields, gathering, treatment and sale of gas. These operations are developed up to the reception point, where the natural gas enters into the transmission system. The reception points are agreed between producers or marketers with shippers (individuals with a transmission contract) for effective delivery, transfer of ownership and responsibility over the traded gas volumes.

The National Gas Regulatory Board (ENARGAS)[11] has competence over the purchase, transmission, distribution, commercialization and storage of natural gas, as well as over the distribution of propane through pipeline networks.

Figure 3.1.1 Argentina: Governmental Authorities Relevant for the Gas Market, in August 2016



References: (1) YPF S.A. acts as official LNG purchase agent on behalf of ENARSA.
Source: Author schematisation.

The State agency ENARSA - created by the government that ended its mandate in December 2015 - has a relevant participation in natural gas and Liquefied Natural Gas (LNG) imports, in the latter case with the support of the State-controlled oil company YPF, through an exclusive purchasing role. However, it should be noted that - at the time of the preparation of the present paper - the administration in office was reviewing ENARSA's role.

[11] Throughout this paper, extensive reference will be made to regulations and statistics of ENARGAS. For further information see http://www.enargas.gov.ar/

Formally, there is an Electronic Gas Market (MEGSA), with responsibility for the resale of transmission capacity and the direct allocation of natural gas to certain unbundled users, but - in practice - most transactions are executed through direct coordination between the operators involved.

The Wholesale Electricity Market Dispatch Operator (CAMMESA) currently concentrates the purchase of natural gas for power-plants, although the current government intends to recreate direct private contracting whenever possible.

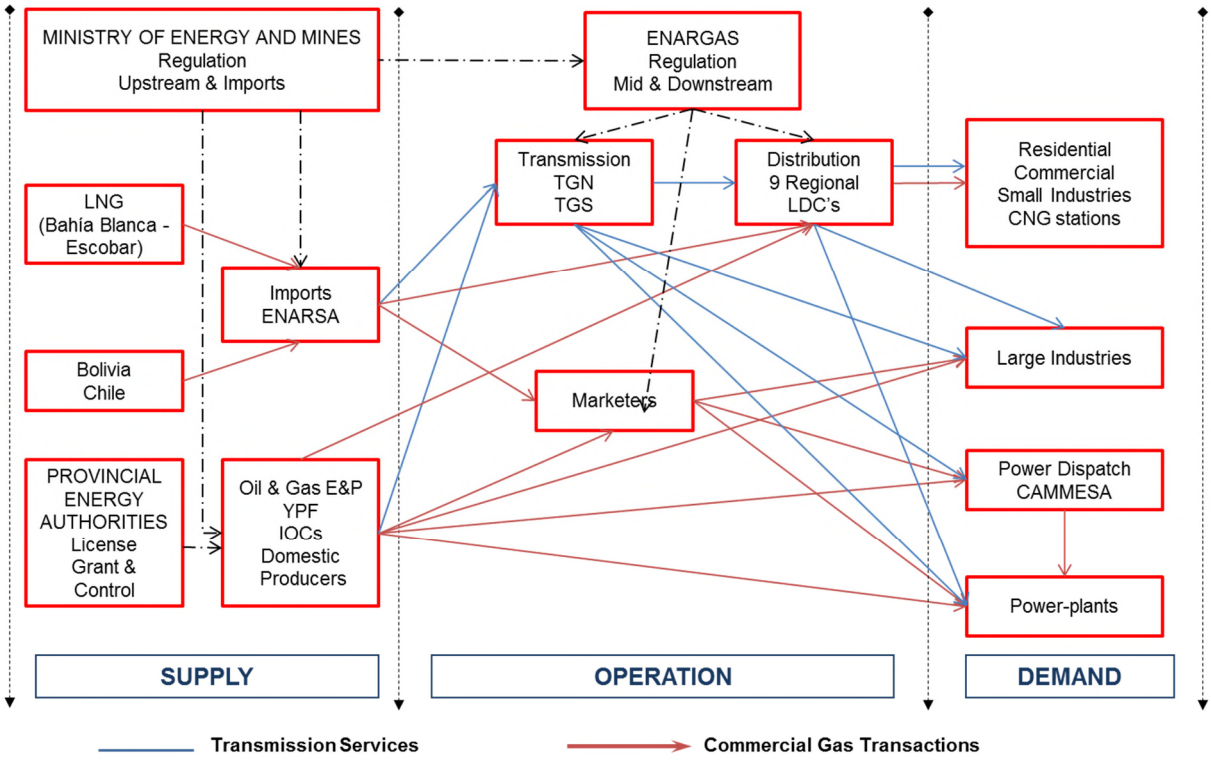
Another relevant national authority is the Ministry of Environment and Sustainable Development (MADS), involved in environmental protection and health matters, the administration of penalties, and the regulation of environmental insurance obligations.

Provincial governments play a significant role in the Argentine gas industry. Following the 1994 Constitutional amendment, successive legislation ruled that the Provinces own the hydrocarbons within their territories and are therefore considered application authorities alongside the national government. The concession licenses are granted by the provincial governments, who also supervise the operations of upstream oil and gas companies.

Provincial administrations also play a relevant role in environmental regulation and oversight, and have partial jurisdiction on taxation matters. The latter also applies for municipal authorities.

Figure 3.1.2 schematically represents the structure of the Argentine gas industry, highlighting the regulatory, commercial and operation interactions between the key governmental agencies and private players.

Figure 3.1.2 Argentina: Structure of the Gas Industry



Source: Author schematisation.

Finally, Figure 3.1.3 identifies the main players - and their roles - in greater detail.

Figure 3.1.3 Argentina: Key Gas Industry Players

Activity	Status	Main Players
Regulation	E&P supervised both by Federal and Provincial Governments. Transportation/Distribution controlled by Gas Regulator.	Ministry of Energy and Mines (MEyM) and Provincial Energy authorities ENARGAS
Exploration and Production (E&P)	Operators are state-controlled and private players. Operators must apply for licenses with Provincial Governments (following the 1994 Constitutional amendment).	YPF (state-controlled) IOCs: Total, Chevron, Exxon, Shell, Wintershall Hybrid: Pan American Energy (BP/Bridas/CNOOC JV), Petrobras Arg., ENAP (Chile) Domestic: Pluspetrol, Tecpetrol, others
Imports of Gas and LNG	Government controlled.	ENARSA
Transmission	Exclusive concession by region. Private ownership. Regional franchise.	TGN (North and East) TGS (South)
Distribution	Private and (partly) government ownership. Exclusive geographical franchise .	Nine Local Distribution Companies (LDCs) 1.Gasnor 2.Gasnea 3.Ecogas Centro 4.Ecogas Cuyana 5.Litoral Gas 6.MetroGAS 7.Gas Natural Fenosa 8.Camuzzi Gas Pampeana 9.Camuzzi Gas del Sur
Consumption	End-users are: Residential, Commercial, CNG Service Stations, Industrial and Power Plants. Own consumption and system losses are significant.	Several associations advocate for final consumers. Large industrial and power-plant users have their own associations.

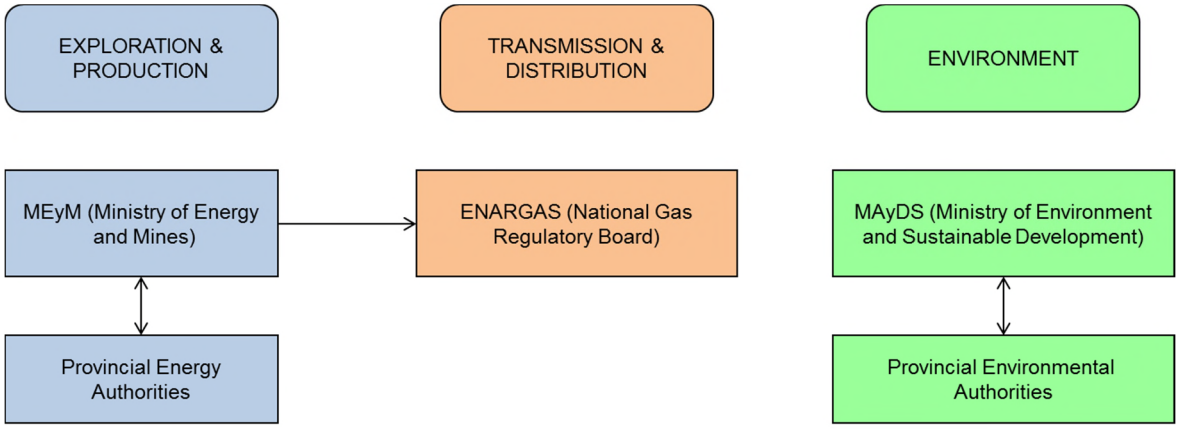
Source: Author schematisation.

3.2 Overview of the regulatory framework

The regulatory framework of the gas industry in Argentina is composed of a relatively complex set of national and provincial laws, decrees and resolutions. In order to facilitate a “helicopter view” of the existing regulations, it seems appropriate to group these under 3 broad categories: exploration and production (E&P), transmission and distribution (T&D), and environmental matters.

Figures 3.2.1 and 3.2.2 respectively summarise the relevant authorities and regulation for the gas industry, for those 3 categories, with a view to provide high level context for some of the topics to be discussed in this paper, focused on unconventional gas development.

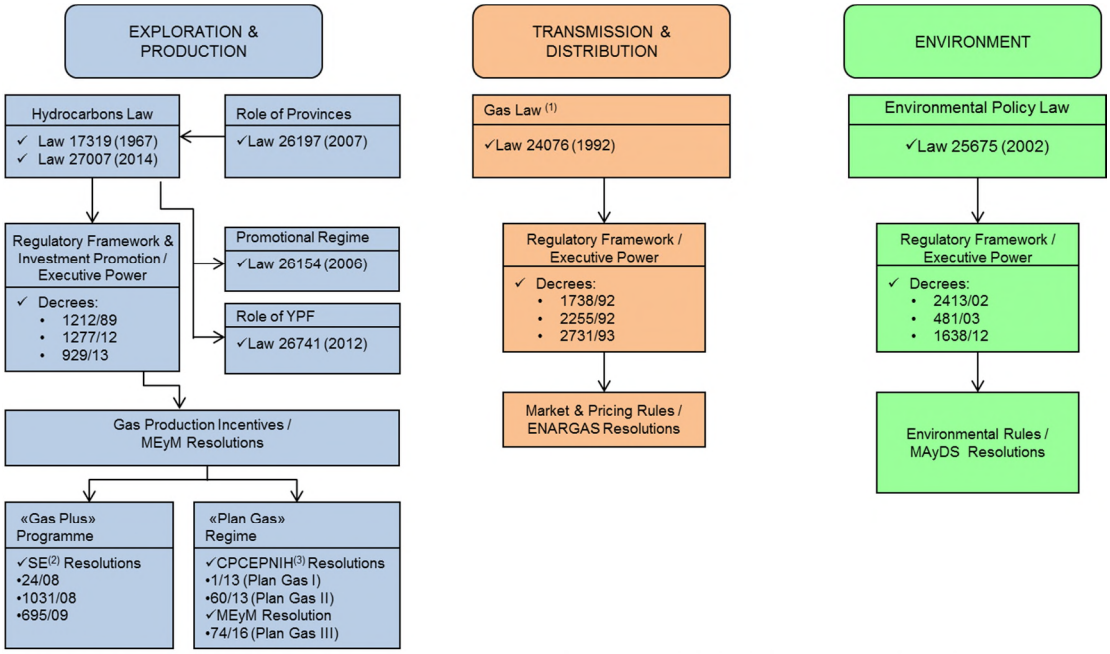
Figure 3.2.1 Argentina: Gas Market Regulatory Framework Overview, in August 2016 – Authorities



Source: Author schematisation.

The stepping stones for these 3 dimensions of the gas industry regulatory framework are: (i) Law 17319, known as the Hydrocarbons Law, mostly focused on E&P; (ii) Law 24076, known as the Gas Law, largely focused on T&D; and (iii) Law 25675 (2002), known as the Environmental Policy Law.

Figure 3.2.2 Argentina: Gas Market Regulatory Framework Overview, in August 2016 - Regulation



References: (1) Partially "suspended" during 2002-2015 by Law 25561 (2002), formally extended by Law 27200 (2015) until Dec. 2017. In practice, Law 24076 is being followed again since Jan. 2016.
(2) SE: Former Energy Secretariat.
(3) CPCEPNIH: Former Hydrocarbons & Strategic Coordination Committee.
Source: Author schematisation.

Brief comments on some of the regulations shown on Figure 3.2.2 follow.

E&P activities

Law 17319 (1967) essentially established the ownership of hydrocarbons, conditions for oil and gas exploration and production, as well as the format, timescales and other conditions of the licenses. This law was modified and/or supplemented by several regulations, notably Laws 26154, 26197 and 27007.

Law 26154 (2006) created promotional regimes for hydrocarbon exploration and production, to be applied in the provinces that adhere to them, as well as in the Argentine Continental Shelf.

Law 26197 (2007) modified the hydrocarbon ownership regime, transferring it from the Nation to the Provinces, based on their geographical location.

Finally, Law 27007 (2014) introduced several significant changes, including a differential treatment for conventional and unconventional hydrocarbons.

Despite the number of decrees issued by the Executive Power, for the purpose of this paper it is worth highlighting Decree 1212 (1989), that established market rules for the oil and gas industry which - despite periods of ad hoc interruptions and distortions - are mostly valid to date; Decree 1277 (2012), aimed at promoting additional gas production; and Decree 929 (2013), destined to incentivise large scale investments, at a time when YPF and Chevron where jointly launching an ambitious unconventional development programme in Vaca Muerta (Neuquén).

Among the numerous resolutions issued by the Ministry of Energy and Mines (and its preceding agencies), for the purpose of this paper it is worth highlighting those that regulate the “Gas Plus” Programme and the so-called “Plan Gas” regime, destined to stimulate additional gas production and injection through pricing incentives that will be covered under Section 3.3.

As previously mentioned, the provincial governments have a key regulatory role in E&P activities, both in the granting of concession licenses and in the supervision of the actual operations.

T&D activities

Law 24076 (1992) defined the subjects, bases, principles, rights and obligations of transmission, distribution, storage and direct purchase of natural gas, at the time of the privatisation of the former State company Gas del Estado, which was subsequently replaced by the 2 transmission and 9 distribution companies shown under Figure 3.1.3. The Gas Law establishes clear restrictions regarding vertical integration (and controlling interests) in the different segments of the value chain.

It is worth mentioning that Article 3 of Law 24076 stipulates that gas imports do not require approval from the Executive Power (whereas exports do). As mentioned under Section 3.1, the government that ended its term in December 2015 had assigned ENARSA a “de facto monopoly” in natural gas and LNG imports. However, this was not supported by any formal energy regulations - but is laterally referred to Argentina’s port authority rulings - and is likely to be replaced by more open market practices by the current administration.

Among the many decrees issued by the Executive Power, it is worth mentioning Decree 1738 (1992) that established the regulations of Law 24076; Decree 2255 (1992), that approved the Basic Rules of the Transmission and Distribution Licenses and the regulations for these services; and Decree 2731 (1993), that provided the final regulation for Article 83 of Law 24076, and established rules for the deregulation of the gas price at wellhead and the creation of short, medium and long term markets.

The numerous resolutions issued by the National Gas Regulatory Board (ENARGAS) set market, pricing and operational rules and standards on an ongoing basis.

Environmental policy

Law 25675 (2002) established guidelines for national environmental policy and “sustainability management”.

Among the decrees issued by the Executive Power, for the purpose of this paper it is worth highlighting Decrees 2413 (2002) and 481 (03), that issued the regulations for Law 25675 and the application authority; and Decree 1638/12, that set out environmental risk assessment guidelines and insurance policy requisites.

Environmental rules and regulations are established both at a national level, by the Ministry of Environment and Sustainable Development (MAyDS) - and its preceding agencies - and at provincial level. It is noteworthy that - in the framework of the development of unconventional oil and gas activities - the government of Neuquén has issued special rulings concerning the use and recycling of water (Decree 1438/12).

Given its potential impact on the future role of the gas industry - especially, in the power sector - it is worth mentioning that Argentina has recently issued substantive legislation to promote the development of renewable energy, through Law 27191 (2015) and Decree 531 (2016). This legislation establishes that the renewable energy share should reach 8% of the country's electricity consumption by Dec. 31, 2017 - and 20% by Dec. 31, 2025 -, as against slightly under 2% recorded in 2014. For this purpose, in 2016 the current government launched ambitious tender processes for the commissioning of renewable-based power generation. The expectation is that - within the next years - wind and solar energy are likely to expand very dynamically, followed by a second-tier of renewables composed of biofuels, biomass, small hydro and geothermal.

3.3 Key activity indicators, pricing and subsidies

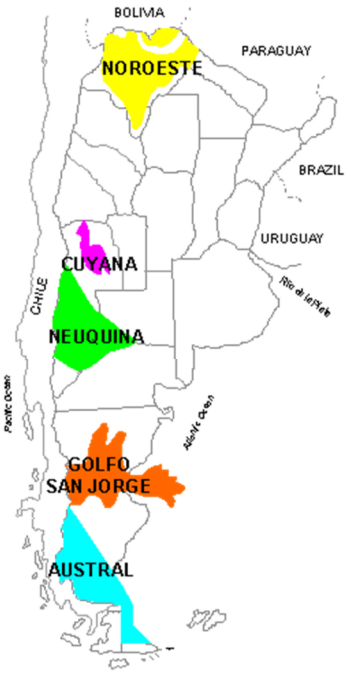
Reserves and production

Argentina has 24 sedimentary basins, but, at the time of the preparation of this paper, hydrocarbon production was confined to the 5 basins shown in Figure 3.3.1: Noroeste[12], Cuyana, Neuquina (hereafter named "Neuquén", to facilitate its identification in English language), Golfo San Jorge and Austral. During Argentina's 100+ years of oil and gas industry track record, approximately 67,000 exploration and production wells have been drilled in these basins.

The remaining 19 basins are deemed to present high geological risk. Throughout their history, roughly 120 wells have been unsuccessfully drilled there.

[12] Geologists consider the "Noroeste basin" an inappropriate term, given that - from a technical viewpoint - it is actually composed of 2 basins: the Cretaceous (to the East) and the Palaeozoic (North and Centre). Natural gas is only produced in the latter.

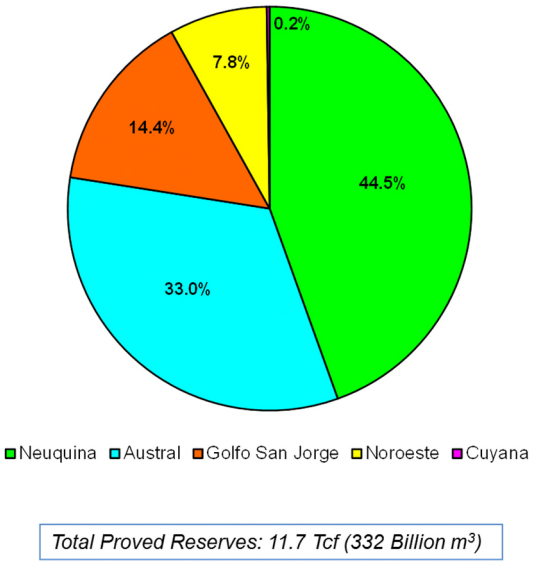
Figure 3.3.1 Argentina: Main Productive Basins



Source: Author schematisation, based on information from the Argentine Institute of Oil and Gas (IAPG).

Figure 3.3.2 presents Argentina's proved natural gas reserves by basin, which totaled 11.7 Tcf (332 billion m^3) as at 12/31/2014[13]. The largest reserves are in Neuquén, with 44.5% of the total, followed by Austral with 33%.

Figure 3.3.2 Argentina: Proved Natural Gas Reserves by Basin, as at 12/31/2014

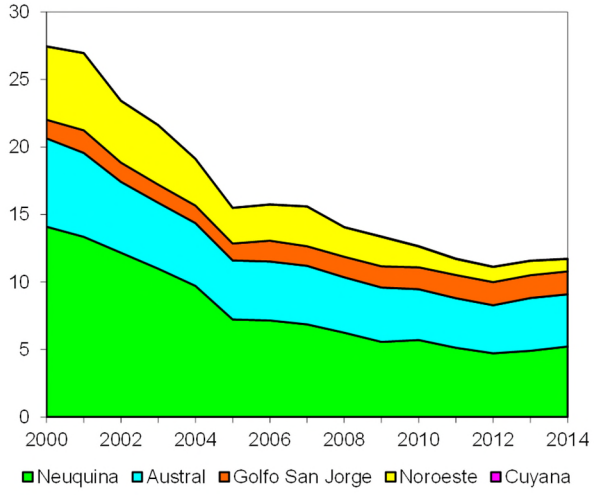


Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

[13] Reserves estimated until the end of the useful life of the fields (and not until the end of the concessions). By Aug. 2016, figures for 12/31/2015 had not yet been published

As shown in Figure 3.3.3, proved natural gas reserves have been declining since the year 2000, mainly due to their sharp fall in the Neuquén basin. Probable gas reserves represent slightly over 40% of the level of proved reserves, for which reason any future substantial improvement of the current situation will heavily rely on the development of the country's unconventional gas resources (mostly shale and tight-sands gas), as described further on.

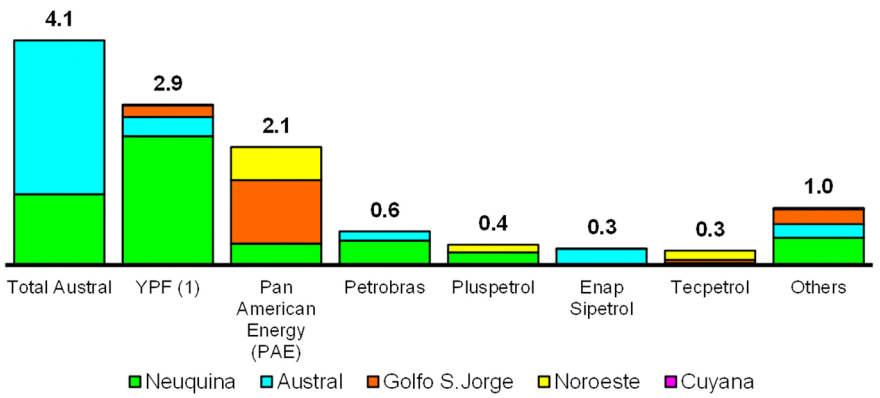
Figure 3.3.3 Argentina: Proved Natural Gas Reserves by Basin - 2000/2014 (Tcf)



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

There is also a strong concentration in proved gas reserves by company, as can be seen in Figure 3.3.4, since the first three operators[14] account for almost 78% of the total. Total Austral, with 35% of the total reserves, and a dominant position in the Austral basin, holds the highest share. It is followed by YPF, the most relevant player in the Neuquén basin, with 25% of the country's reserves. Pan American Energy (PAE) ranks third, and is the leader in the Golfo San Jorge basin, with almost 18% of the total reserves.

Figure 3.3.4 Argentina: Proved Natural Gas Reserves by Operator, as at 12/31/2014 (Tcf)

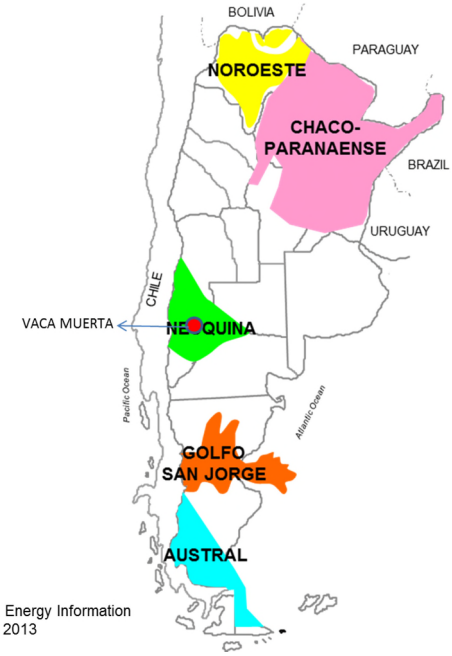


Reference: (1) YPF includes former Apache.
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

[14] Argentina's public E&P statistics by companies are assigned to "operators". In the case of joint-ventures, this implies that reserves and production by "owners" can be found in corporate (and - if applicable - balance sheet) data, which take into account the actual participation of each partner.

Figure 3.3.5 illustrates the five basins containing shale gas resources, four of which are currently productive (Noroeste, Neuquén, Golfo San Jorge and Austral), whereas one is not (Chaco-Paranaense). Most of the shale oil and gas resources are located in the Neuquén basin, and - in particular - in the worldwide known Vaca Muerta formation.

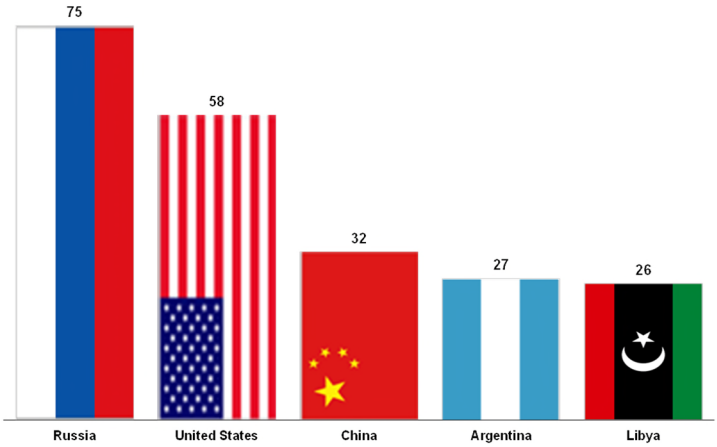
Figure 3.3.5 Argentina: Basins containing Shale Resources



Source: Redrawn, based on U.S. Energy Information Administration (EIA) report, June 2013

As shown in Figures 3.3.6 and 3.3.7, according to a survey published by the US Energy Information Administration (EIA) in June 2013[15], further updated in 2015, the estimated technically recoverable shale oil and gas resources of Argentina - respectively - rank fourth and second in the world, in the latter case totaling 802 Tcf. Further detail is provided under Section 3.5

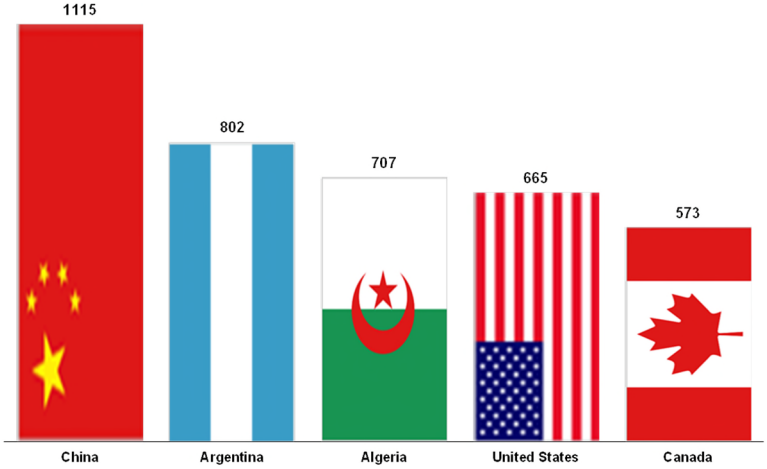
Figure 3.3.6 Argentina: Estimated Technically Recoverable Shale Oil Resources – 2013 (Billion Bbl)



Source: U.S. Energy Information Administration (EIA) - DOE / Advanced Resources International (ARI), June 2013.

[15] (EIA, 2013), (EIA, 2015)

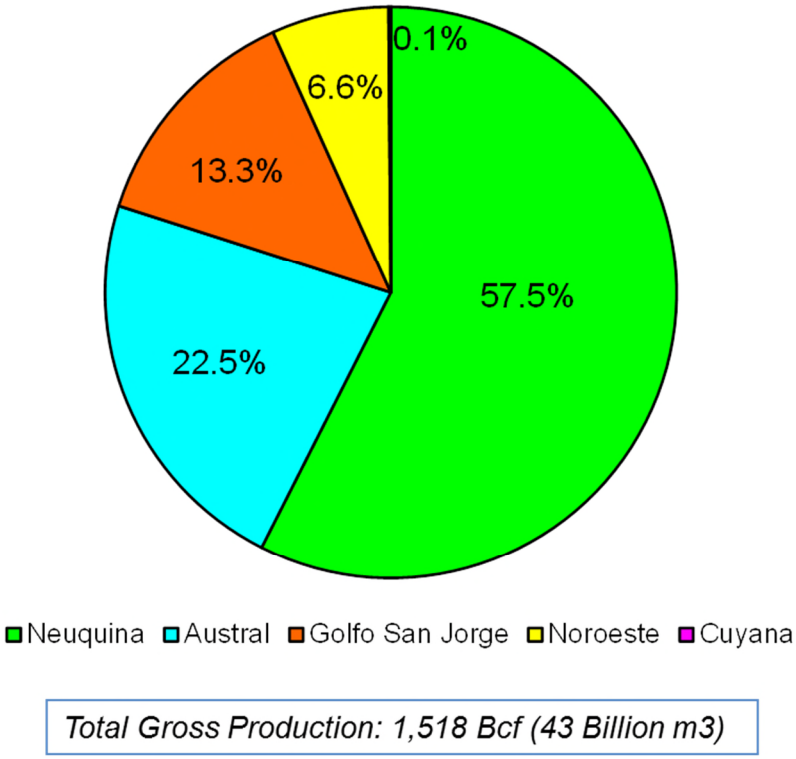
Figure 3.3.7 Argentina: Estimated Technically Recoverable Shale Gas Resources – 2013 (Tcf)



Source: U.S. Energy Information Administration (EIA) - DOE / Advanced Resources International (ARI), June 2013.

Figure 3.3.8 presents Argentina's gross natural gas production by basin, which totaled 1.5 Bcf (43 billion m^3) in 2015. Once again, the most relevant basin is Neuquén, with 57.5% ot the total, followed by Austral with 22.5%.

Figure 3.3.8 Argentina: Gross Natural Gas Production by Basin - 2015

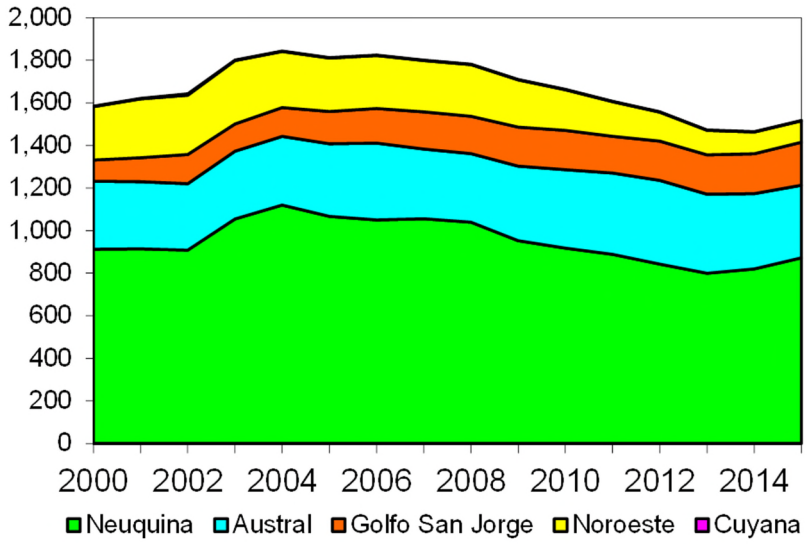


Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

As can be seen in Figure 3.3.9, Argentina's gross natural gas production had been increasing until 2004, when it started to decline substantially, especially in the Noroeste and Neuquén basins.

A good indicator of the maturity of the producing fields is the evolution of the operating pressure. In the year 2000, 58% of the gas production originated at high pressure - and only 17% at low pressure - fields, whereas currently the latter contribute with approximately two thirds of the total volumes.

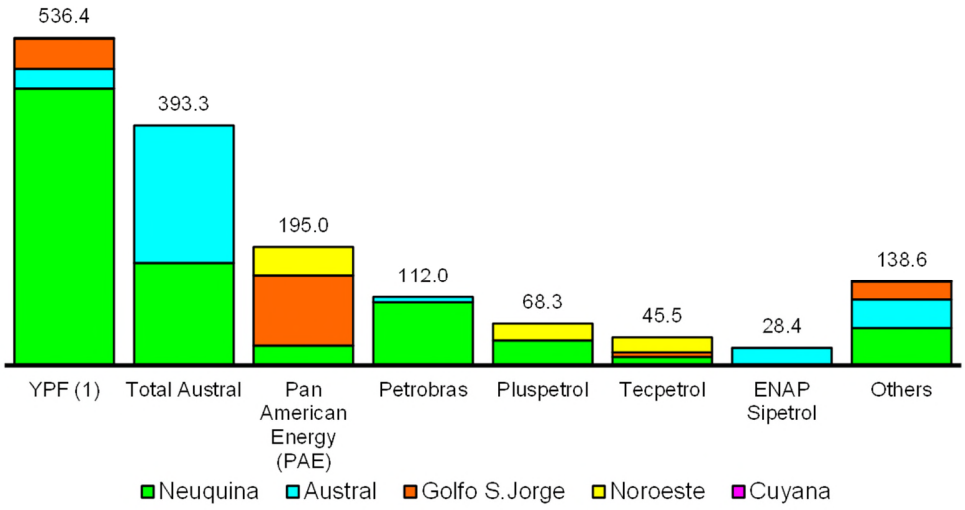
Figure 3.3.9 Argentina: Gross Natural Gas Production by Basin - 2000/2015 (Bcf)



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Figure 3.3.10 describes the 2015 production by operators, led by YPF, with 35% of the total - and a dominant position in the Neuquén basin -, and followed by Total Austral - the most relevant player in the Austral basin - with 26%, and Pan American Energy (PAE) – the leader in the Golfo San Jorge basin – with 13%. The first five operators - the three previously mentioned companies, plus Petrobras and Pluspetrol - account for 86% of the total production.

Figure 3.3.10 Argentina: Gross Natural Gas Production by Operator – 2015 (Bcf)

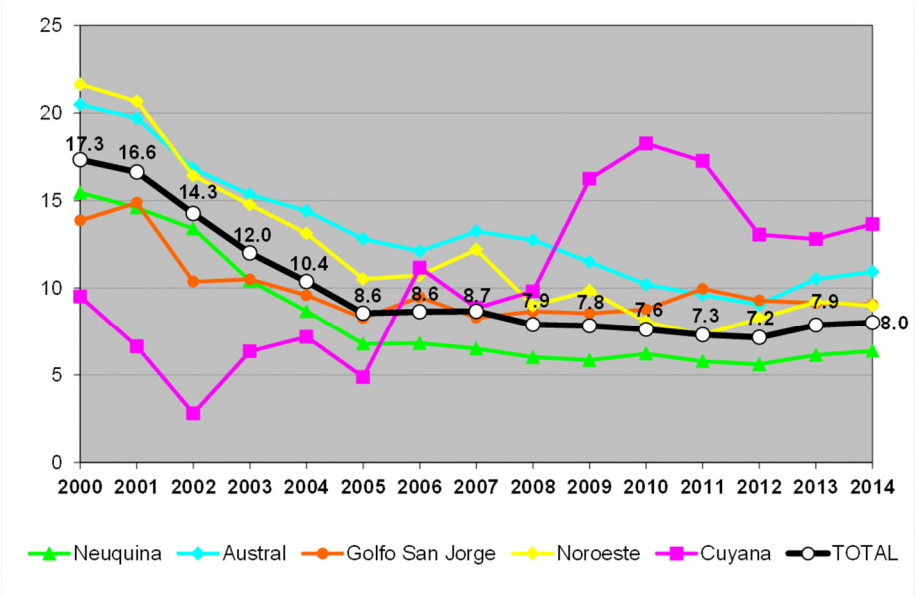


Reference: (1) YPF includes former Apache.
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Despite this sharp production drop, the proved Reserves Life Index (RLI) has been steadily declining since the late 1970s, when the incorporation of the giant field of Loma La Lata - in Neuquén - had resulted in the doubling of the existing reserves. Figure 3.3.11 shows that the reserves/production ratio has fallen from 17 to 8 years of remaining production between 2000 and 2014.

Figure 3.3.11 Argentina: Natural Gas Proved Reserves/Gross Production Ratio by Basin - 2000/2014

(Years of remaining production)



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Transmission

The map in Figure 3.3.12 outlines the Argentine gas transmission system, operated by 2 companies - TGN (Transportadora de Gas del Norte) and TGS (Transportadora de Gas del Sur) -, that were created in December 1992, following the privatisation of the former state company Gas del Estado, which until that time had the monopoly of gas transmission and distribution services throughout the whole country.

The domestic gas market is served by 5 trunk gas pipelines: Norte and Centro-Oeste operated by TGN and Neuba (standing for Neuquén-Bahía Blanca) I and II, and San Martín, operated by TGS. In addition, there are several smaller regional pipelines. The total nominal (name plate) capacity of these trunk and regional lines is 151 MMm^3/d (approx. 5,330 MMcf/d), with the 3 pipelines originating in the Neuquén basin (Centro-Oeste, and Neuba I and II) accounting for 78 MMm^3/d (approx. 2,750 MMcf/d).

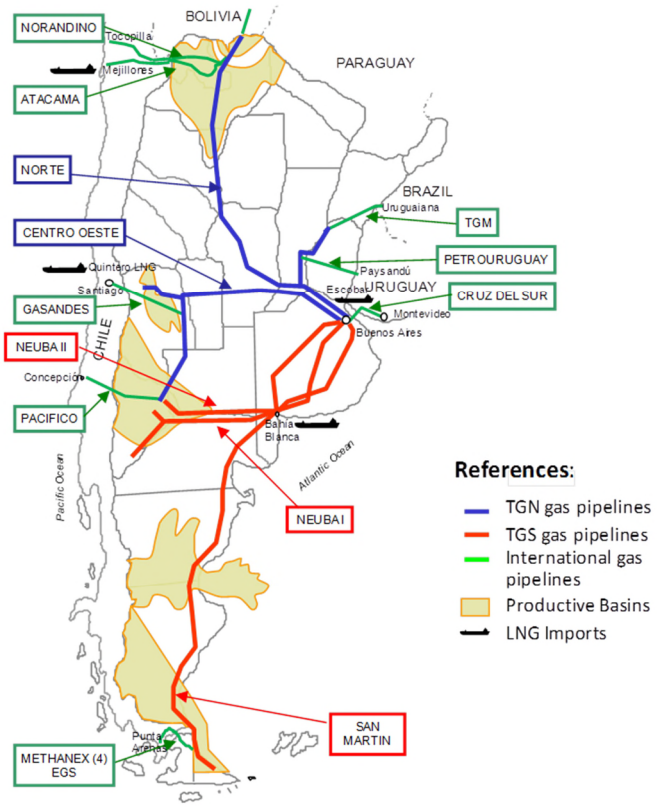
The map also shows Argentina's export gas pipelines to Chile, Brazil and Uruguay. From 1995, when the first line to (the extreme South of) Chile was built, until 2001, when the Cruz del Sur gas pipeline to Uruguay was commissioned, Argentina built 11 export gas pipelines, for a total nominal (name plate) capacity of almost 47 MMm^3/d (approx. 650 MMcf/d), with the 2 pipelines originating in the Neuquén basin (Gasandes and Gasoducto del Pacífico) accounting for 14 MMm^3/d (almost 500 MMcf/d).

Due to the aforementioned decline in local gas production, the injection capacity strongly decreased as of 2004, with significant impacts on the utilisation factor of both the domestic and export pipelines. In 2015, the average annual load factor of the domestic trunk gas pipeline system was approx. 65% (with higher utilisation in TGN than in TGS), whereas - with the exception of the transportation of

marginal volumes destined to Uruguay and Chile - the export lines were virtually “out of order”. Moreover, in 2016 the flow of gas in two of these pipelines (Norandino and Gasandes) was reversed, and they started serving as import sources from Chile. This subject is covered in greater depth under Section 3.4.

Finally, regarding the infrastructure originating in the Neuquén basin, there is approximately one third of spare capacity available to transport future unconventional gas production increases. This is of key importance for the development of Vaca Muerta, as it implies that - aside from inevitable gathering system constraints - no transmission bottlenecks will have to be faced in the short and medium term.

Figure 3.3.12 Argentina: Main Facilities of the Natural Gas Transmission System, in August 2016



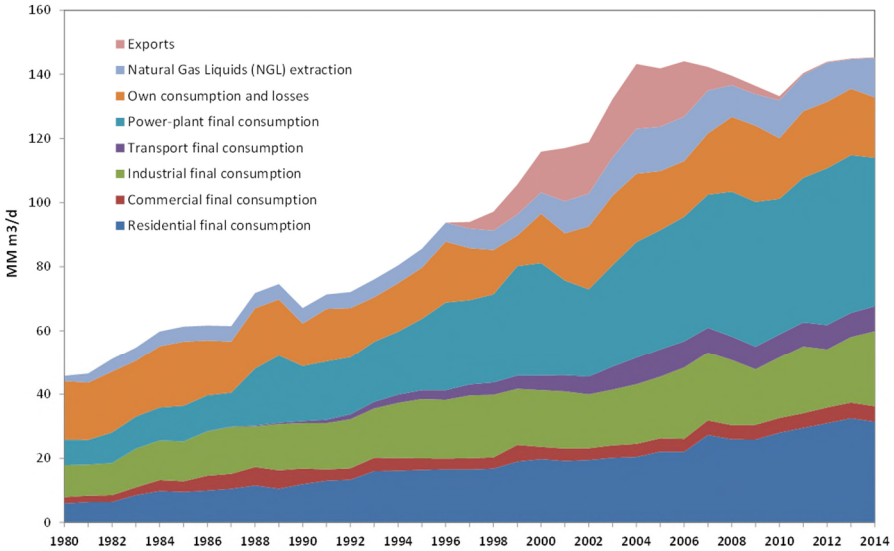
Source: Based on information from the national gas regulatory board (ENARGAS), TGN and TGS.

Utilisation

Figure 3.3.13 illustrates the evolution of natural gas utilisation by destination - both for domestic consumption and exports - during the 1980/2014 period. Within a significantly dynamic internal market, the segments that experienced the largest growth in natural gas use in Argentina were (i) power generation; (ii) residential; (iii) industrial and (iv) transport, following the introduction of Compressed Natural Gas (CNG) as a vehicle fuel in the early ‘90s.

In 2014, power generation accounted for 31.9% of total gas utilisation, followed by the residential and industrial sectors, with 21.6% and 16.3%, respectively. It is noteworthy that own consumption and losses represented 12.9%, whereas 8.5% was destined to Natural Gas Liquids (NGL) extraction in processing plants.

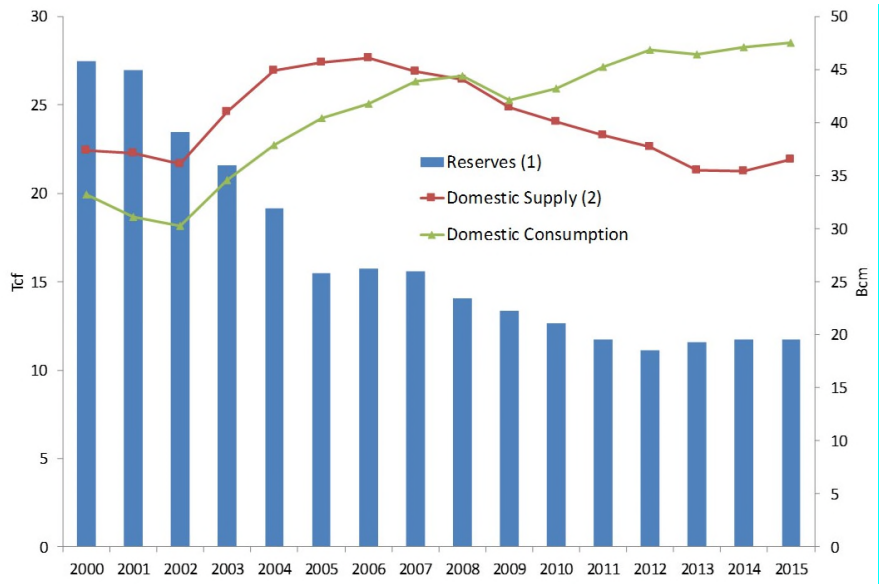
Figure 3.3.13 Argentina: Natural Gas Utilisation, by Destination – 1980/2014



References:
Total natural gas utilisation, both as primary and secondary energy.
NGL extraction reflects gas used to produce ethane, propane and butane (LPG), pentane (gasoline) and others in treatment plants.
Own consumption and losses include use at oil fields, flaring, losses in transportation and distribution, and statistical adjustments.
Consumption in power-plants includes generation for public networks and self-production.
Final industrial consumption includes non-energy (mainly petrochemical) use.
Source: Based on information from the Argentine National Energy Balances.

Figure 3.3.14 presents the evolution of Argentina's natural gas reserves, domestic supply and consumption during 2000/2015. As mentioned under Section 2.2, "artificial pricing" policies followed during the 2002/2015 period boosted internal consumption and led to a sharp decline in domestic production, turning the country into a net gas importer as of 2008 - and into a net oil and gas importer as of 2011. This structural imbalance between domestic demand and supply of hydrocarbons, as well as the associated fiscal impact of large-scale imports, constitute a key conditioning factor for policy-makers, in a country in which natural gas contributes 51% of the total energy supply.

Figure 3.3.14 Argentina: Natural Gas Reserves, Production and Domestic Consumption – 2000/2015



Reference: (1) 2015: Not published to date, reproduces 2014 value.
(2) Excludes gas flared or recycled. Includes natural gas produced for Gas-to-Liquids transformation.
Source: Based on information from BP Statistical Review of World Energy 2016.

Imports and exports

Argentina has a background as an importer of natural gas from Bolivia that goes back to 1972. Transactions were interrupted between 1999 and 2004, as a consequence of the significant domestic gas production available at that time.

In 2004 imports re-started, following the execution of direct contracts between producing companies in both countries. The total contract volume amounted to 7 MMm3/d (247 MMcf/d).

In 2006 Bolivia and Argentina, now at government level (through the State-controlled companies YPFB and ENARSA), signed a 20-year long contract for an initial volume of 7.7 MMm3/d (272 MMcf/d), which could rise up to a maximum of 27.7 MMm3/d (978 MMcf/d) in the long term.

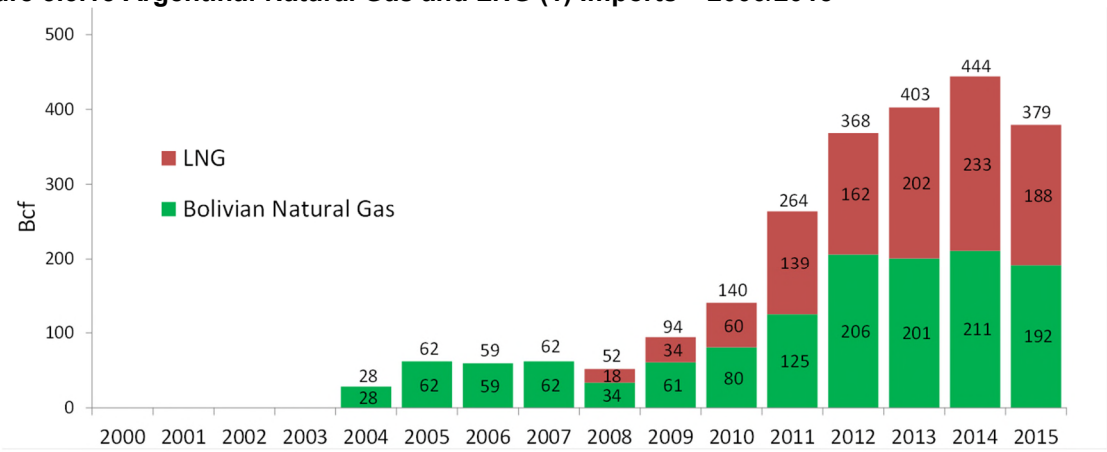
As a result of the requirements of its domestic consumption and (especially) its contract with Brazil - which has higher delivery priority - it was not feasible for Bolivia to fulfill its commitment to Argentina. This situation resulted in the reformulation of the agreement, respecting the anticipated maximum value but readjusting contract phasing.

Figure 3.3.15 reports natural gas volumes imported from Bolivia since 2004 and in the form of Liquefied Natural Gas (LNG) from other countries since 2008. As of that year, due to its insufficient local production and Bolivia's constraints, Argentina started to import LNG through a regasification ship berthed for that purpose at Ingeniero White, near the city of Bahía Blanca, in the South of the Province of Buenos Aires, from where the gas is injected into the trunk gas pipelines that reach the Greater Buenos Aires area. From 2011 onwards, an additional regas ship has been located at Escobar, in the North of the Province of Buenos Aires, from where the gas is also injected into the trunk gas pipeline ring of the Greater Buenos Aires area.

As already mentioned, in 2016 Argentina started importing natural gas from Chile, through two pipelines - Norandino and Gasandes – that transport volumes actually received by the exporting party as LNG, at its Mejillones and Quintero regasification facilities.

This subject is developed in greater depth under Section 3.4.

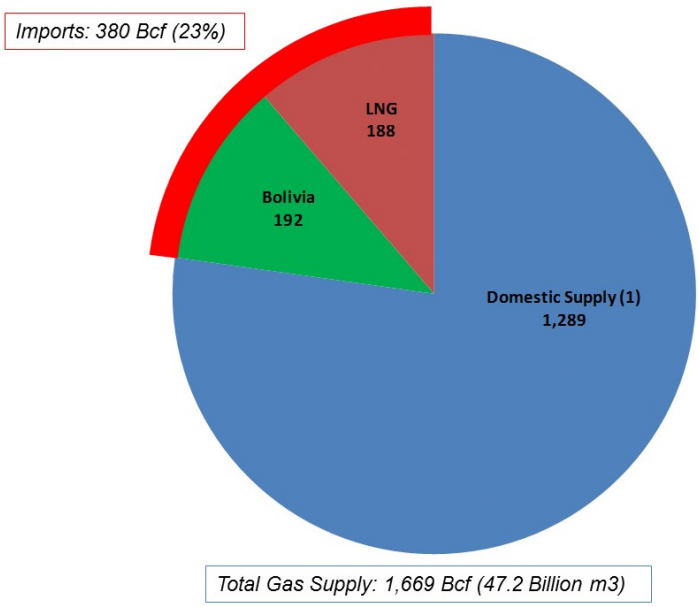
Figure 3.3.15 Argentina: Natural Gas and LNG (1) Imports – 2000/2015



Reference: (1) Liquefied Natural Gas.
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Figure 3.3.16 shows Argentina's resulting gas supply mix for 2015: 77% was covered by domestic production and the remaining 23% by Bolivian and LNG imports.

Figure 3.3.16 Argentina: Natural Gas Supply by Source - 2015

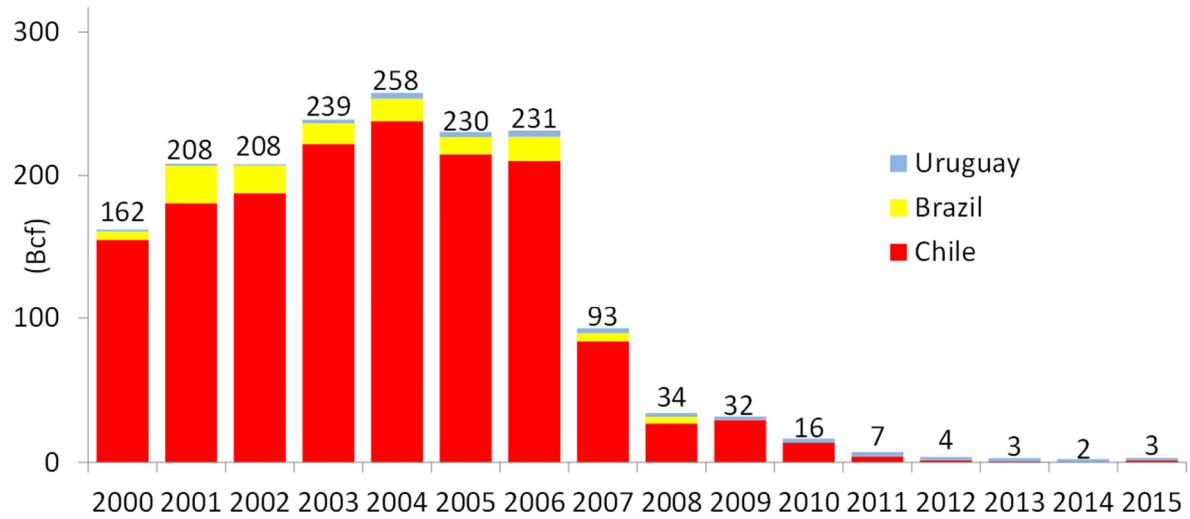


Reference: (1) Excludes gas flared or recycled. Includes natural gas produced for Gas-to-Liquids transformation
Source: Imports: Argentine Ministry of Energy and Mines (MEyM).
Domestic Supply: BP Statistical Review of World Energy 2016.

As can be seen in Figure 3.3.17, exports through Argentina's 11 existing gas pipelines to neighbouring countries grew until 2004, when they reached a peak of 258 Bcf (approx. 20 MMm^3/d), 92% of which were directed to Chile. However, when it became apparent that local production was insufficient, the Argentine government prioritised the supply of the domestic market, and from 2005 onwards it began to restrict exports significantly and to levy taxes on them that increased their cost, in order to pass through to buyers part of the larger costs that Argentina was in turn paying for its growing natural gas imports from Bolivia and in the form of LNG.

Thus, exports were strongly reduced to an almost insignificant level, representing only 3 Bcf in 2015.

Figure 3.3.17 Argentina: Natural Gas Exports – 2000/2015



Source: Based on information from the national gas regulatory board (ENARGAS).

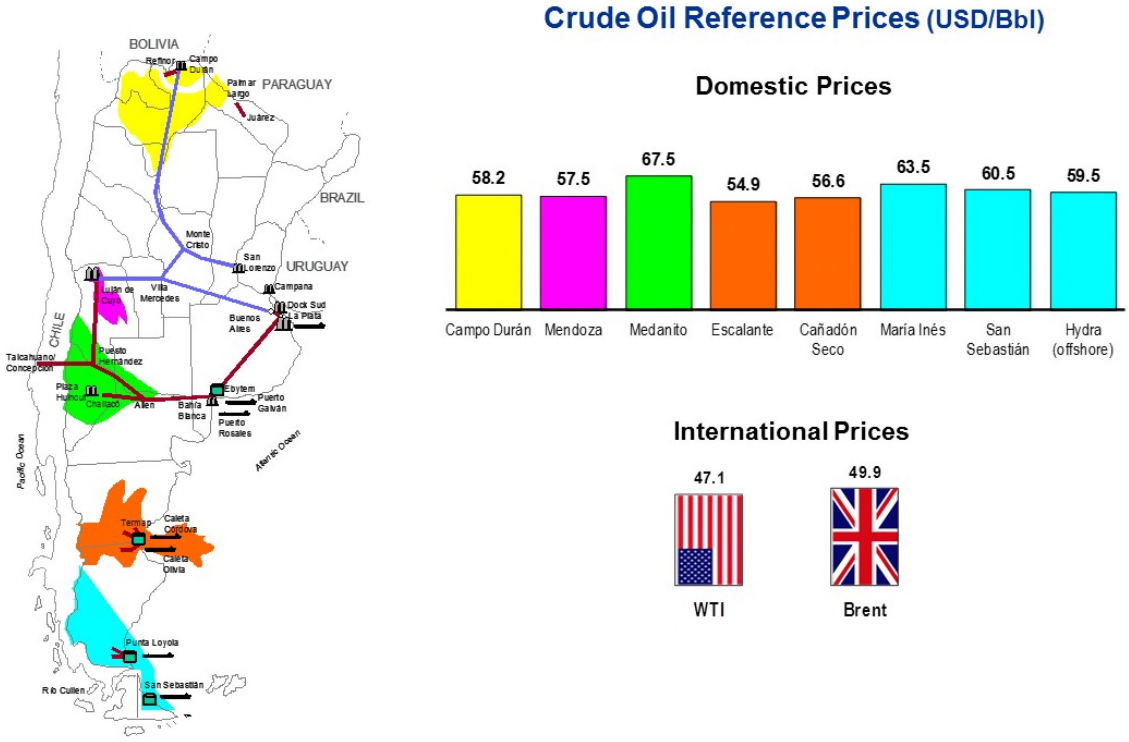
Reference prices

Figure 3.3.18 presents Argentina's domestic crude oil prices, as at Aug. 15, 2016, as well as Brent and WTI quotations[16] at the same date. As can be seen, local prices are currently "decoupled" from the international markets, with light Neuquén basin crude – Medanito - quoted at 67.50 USD/bbl and heavy Golfo San Jorge basin crude - Escalante - priced at 54.90 USD/bbl. Exports have special subsidies.

Crude oil prices are formally deregulated in Argentina, but are - in practice - set by "agreement" between the national government and the producers. During many years, "decoupling" translated into domestic prices that were lower than export parity levels (at a time when Argentina was a net exporter). Following the sharp fall in international oil prices that started in the second half of 2014, the Kirchner administration decided to keep internal prices at higher levels than international benchmarks, in order to mitigate the potentially negative impact of the market downturn on the industry in general and shale oil investments in particular.

The Macri administration has indicated its preference to "couple" the Argentine and international oil markets, but decided to temporarily maintain higher domestic prices, in principle until 2017, in the hope that the gradual recovery of international prices may smooth the "coupling" process. In this line, during the second half of August 2016, the government and the producers "agreed" to reduce the prices shown on Figure 3.3.18 by 2% per month until October, when Medanito should reach 59.40 USD/bbl and Escalante 51.60 USD/bbl. The intention of the government is to start 2017 with light crude prices in the range of (or somewhat below) 60 USD/Bbl, with a view to "couple" local prices with Brent import parity levels (discounted by quality differentials) as soon as possible.

Figure 3.3.18 Argentina: Domestic and International Oil Prices, as at August 15, 2016



Source: Authors, based on information from the Argentine Ministry of Energy and Mines (MEyM) and preciopetroleo.net.

[16] http://www.preciopetroleo.net/

Figure 3.3.19 illustrates the range of producer and import prices coexisting at the beginning of 2016, as a result of the policies applied for over a decade, within a regulatory philosophy known as "pricing segmentation", that combined ad hoc quotation differentiations by basins, end-users and "pre-existing" or (more recently) "new" gas with the extensive use of subsidies and the decoupling of domestic and international markets.

As in the case of crude oil, during many years "decoupling" translated into domestic producer prices that were lower than import parity levels, but - since 2015 - they are higher (for certain special incentive regimes). Similarly, the Macri administration decided to temporarily maintain these higher domestic prices, in principle until December 31, 2017, when the contracts signed within one of these incentive programmes - known as "Plan Gas" - will expire. In line with this, at the end of August 2016 the government was assessing two possible ways forward: (i) "coupling" domestic producer gas prices with LNG import parity quotations plus regasification costs, as of January 1, 2018; and (ii) adjusting the producer prices for "pre-existing" gas bi-annually (in October and April of each year), during 2016/2019, with a view to reach approx. 6.5-7.0 USD/MMBtu at the end of this period. The latter seemed to be the more likely option.

Figure 3.3.19 shows the producer and import prices in force by March 2016, whereas Figure 3.3.20 updates this information as of August 2016. In between, significant gas price and end-user tariff increases had been decided by the government, as of April 1, 2016, but - following numerous judiciary injunctions - on August 18 the Supreme Court suspended this measure for the residential segment, and ordered the government to "reinstate" the March 31 rates and propose new (residential) tariffs in a public hearing (that has been called for September 16). Even if the prices and tariffs for other consumer sectors were not affected by the Supreme Court ruling, at the end of August – and due to political pushback - the government had anticipated its intention to review its April decisions, with a view to propose more moderate hikes in end-user tariffs, for all market segments.

Consequently, the values shown on the upper left side of Figure 3.3.20 ("domestic commodity prices in Buenos Aires") should be regarded as provisional, and as an illustration of the complexities derived from the "segmentation system" that this administration inherited from the previous government, and will find very challenging to replace by a more systemic approach in the short term.

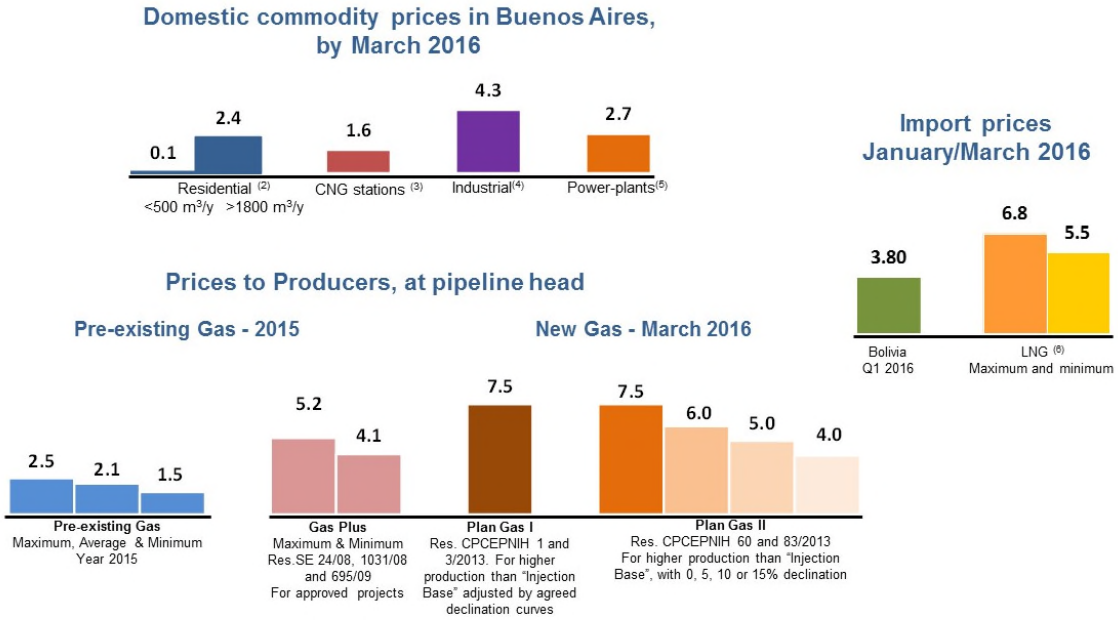
The lower side of Figures 3.3.19 and 3.3.20 shows gas prices to producers at the well-head, under the different existing regimes. "Pre-existing" average gas prices reflect the 2015 mix of the amounts paid by final users. The prices applicable to certain "incentive programmes" designed to stimulate the production of incremental gas volumes - such as "Gas Plus", and "Plan Gas", with maximum prices of 5.2 and 7.5 USD/MMBtu, respectively - are substantially higher, and reflect the values paid to those producers that have qualified for these special regimes, which were - respectively - put in place in 2008 and 2013. The differential price between "pre-existing" (i.e., "old") and "new" gas production is actually subsidised by the State, through the national budget.

From an unconventional gas development standpoint, it is noteworthy that both tight-sands and shale gas production volumes have benefited from the higher prices regulated by the aforementioned incentive programmes.

On the right hand side, both figures present the relevant import price benchmarks at the reference dates. By March 2016 (Figure 3.3.19), these were Bolivian gas[17] and LNG, both of which were priced lower than the 7.5 USD/MMBtu maximum value applicable for "Plan Gas". By August 2016 (Figure 3.3.20), the recently commissioned seasonal gas imports from Chile added a third benchmark, at prices higher than Bolivian gas or LNG but still below maximum "Plan Gas" levels.

[17] http://www.hidrocarburosbolivia.com/

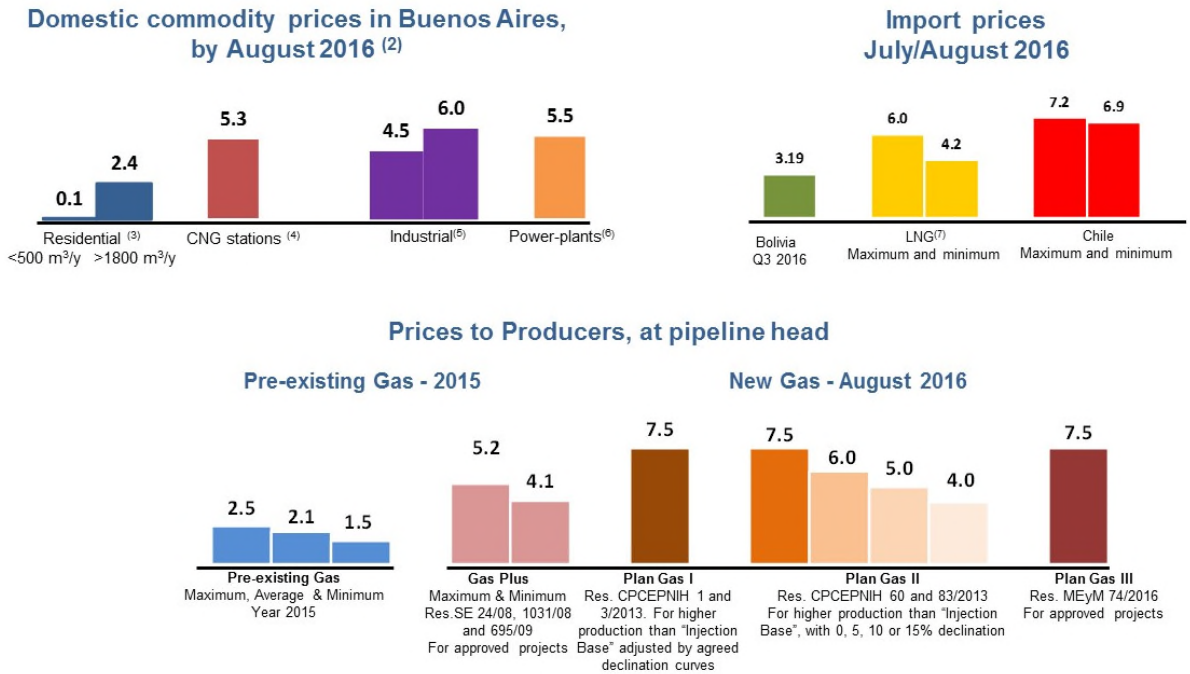
Figure 3.3.19 Argentina: Producer and Import Gas Prices,in March 2016 (USD/MMBtu)(1)



References:
(1) Exchange rate: 1 USD = 15.0 Arg $. (2) Gas price to residential users R1 and R34, in Buenos Aires City. (3) Price to CNG service stations, in Buenos Aires City. (4) Price to a high-level consumption industry, in Buenos Aires Province. (5) Price to a representative power-plant, in Buenos Aires City. (6) Commodity prices in Bahía Blanca and Escobar. Excludes regasification costs (0.8 – 1.1 USD/MMBtu).

Source: Authors, based on information from the Argentine Ministry of Energy and Mines (MEyM), MetroGAS and hidrocarburosbolivia.com.

Figure 3.3.20 Argentina: Producer and Import Gas Prices, in August 2016 (USD/MMBtu) (1)



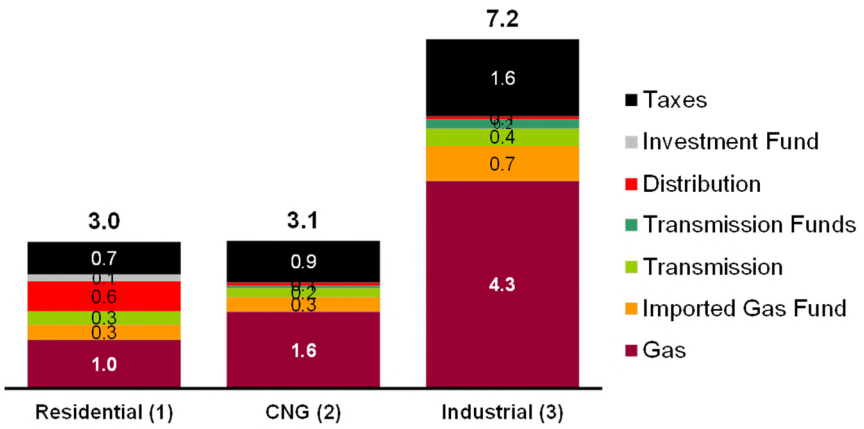
References:
(1) Exchange rate: 1 USD = 15.0 Arg $. (2) On Aug. 18, 2016, the Argentine Supreme Court suspended residential price increases issued by the government (as of April 1), instructing it to call for public hearings in September. (3) Gas price to residential users R1 and R34, in Buenos Aires City. (4) Price to CNG service stations, in Buenos Aires City. (5) Price to a high-level consumption industry, in Buenos Aires Province. (6) Price to a representative power-plant, in Buenos Aires City. (7) Commodity prices in Bahía Blanca and Escobar. Excludes regasification costs (0.8 – 1.1 USD/MMBtu).

Source: Authors, based on information from the Argentine Ministry of Energy and Mines (MEyM), MetroGAS and hidrocarburosbolivia.com.

Figures 3.3.21 and 3.3.22 describe the natural gas price structure for representative residential and industrial end-users, and Compressed Natural Gas (CNG) stations, in the City of Buenos Aires, in March and August 2016[18]. The implications of the August 18 Supreme Court ruling that suspended the April tariff increases for residential consumers[19], as well as the (possibly provisional) validity of the CNG and industrial tariffs reflected in Figure 3.3.22 - in view of the uncertain outcome of the September 16 public hearing - are equally applicable.

Consequently, as in the case of the producer and import prices, the value of the end-user price structure figures (3.3.21 and 22) lies more in their ability to show the different components - and complexity - of final tariffs than in reporting absolute values that may change substantially in October or November, once the new rate structure to be submitted to the September 16 public hearing is approved.

Figure 3.3.21 Argentina: Representative Natural Gas End-User Average Price Structure in Buenos Aires City, in March 2016 (USD/MMBtu)

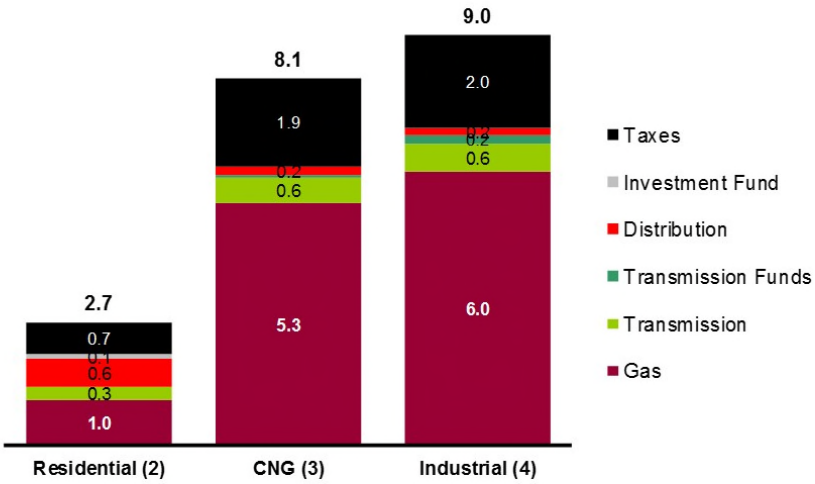


References:
(1) End-user tariffs, including all applicable taxes and an LNG import fund. Annual consumption: 1,115 m^3. Exchange rate: 1 USD = 15.0 Arg $.
(2) Tariffs to CNG stations in Buenos Aires city. Annual consumption: 1.5 MMm^3.
(3) Tariffs including gas transmission fiduciary funds and all taxes, except VAT. Annual consumption: 10.8 MMm^3. Load Factor= 100%.
Source: Authors, based on information from MetroGAS.

[18] Useful additional information can be found on http://www.metrogas.com.ar/

[19] Given that the Supreme Court ordered the government to "reinstate" the residential rates applicable on March 31, 2016, the reader might feel confused by the fact that the residential tariff - including taxes - reported for August (2.7 USD/MMBtu), in Figure 3.3.22, is actually lower than the one shown for April (3.0 USD/MMBtu). This is due to the fact that - on the occasion of the issuance of the (later suspended) April 1 tariffs - the government abrogated the so-called "Imported Gas Fund" - shown in orange on Figure 3.3.21 -, for which reason the (March) "pre-existing" rate structure is not identical to the "current" one (in August 2016).

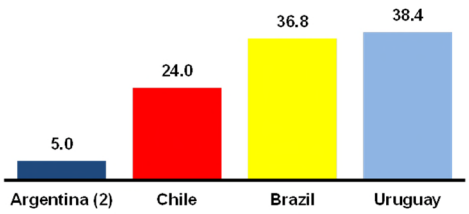
Figure 3.3.22 Argentina: Representative Natural Gas End-User Average Price Structure in Buenos Aires City, in August 2016 (1) (USD/MMBtu)



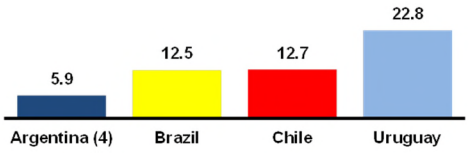
References:
(1) On Aug. 18, 2016, the Argentine Supreme Court suspended residential price increases issued by the government (as of April 1), instructing it to call for public hearings in September.
(2) End-user tariffs, including all applicable taxes. Annual consumption: 1,115 m^3. Exchange rate: 1 USD = 15.0 Arg $.
(3) Tariffs to CNG stations in Buenos Aires city. Annual consumption: 1.5 MMm^3.
(4) Tariffs including gas transmission fiduciary funds and all taxes, except VAT. Annual consumption: 10.8 MMm^3. Load Factor= 100%.
Source: Authors, based on information from MetroGAS.

Figure 3.3.23 Southern Cone: Comparison of Representative End-User Prices for Natural Gas, in June 2015 (USD/MMBtu)

A) Residential Users (1) (Including Taxes):



B) Large Industrial Users (3) (Without Taxes):



References: (1) Annual consumption: Standard consumer in each country. Exchange rate: 1 USD = 9.04 Arg $.
(2) Average price for residential users in Buenos Aires city. Annual consumption: 1,115 m^3.
(3) Average price without taxes for representative industrial consumers in each country.
(4) Tariffs including gas transmission fiduciary funds and all taxes, except VAT.
Annual consumption: 10.8 MMm^3. Load Factor= 100%.
Source: Argentine Gas Distributors' Association (ADIGAS), based on MetroGAS survey: "International Natural Gas Tariff Comparison for Residential and Industrial Customers – June 2015".

Figure 3.3.23 shows a comparison of representative residential and industrial gas prices in the City of Buenos Aires, against those applied to similar end-users in Brazil, Chile and Uruguay, as of June 2015. The disparity between Argentine prices and those in force in its neighbouring countries is remarkable[20]. The current level of residential gas tariffs - following the previously mentioned Supreme Court ruling – remains unchanged - in Argentine pesos - with regard to June 2015, but the USD values have been impacted by significant currency exchange variations as of December 2015 (for which reason "current" August 2016 tariffs are lower - in foreign currency – than those reported for June 2015).

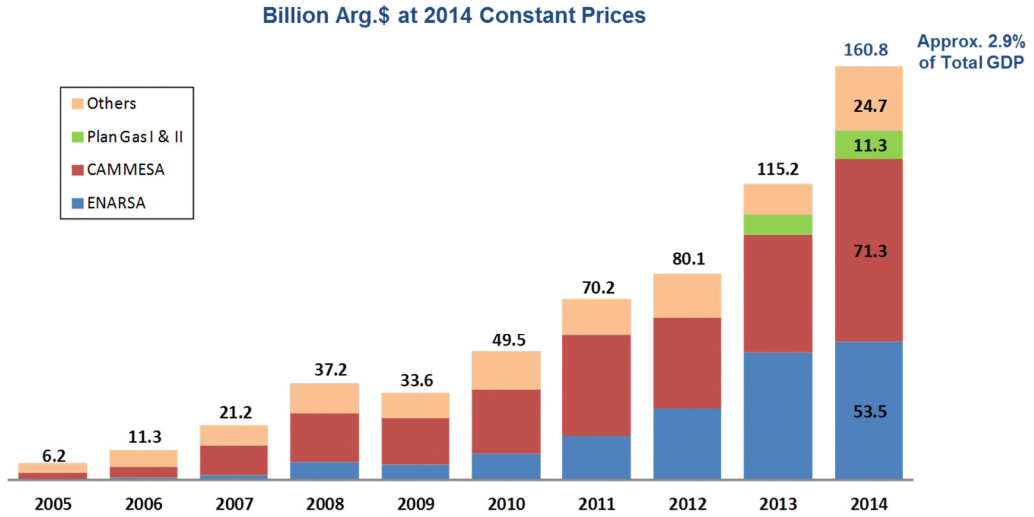
Subsidies

After over a decade of "artificial pricing" policies, domestic energy state subsidies21 - both on the demand and supply sides - became increasingly significant in Argentina, attaining a level equivalent to 3% of GDP in 2014, as can be seen in Figure 3.3.24. This proportion increased to approximately 4% of GDP in 2015.

In the past, these subsidies were mostly destined to cover domestic vs. international price differentials to finance liquid fuel, natural gas and LNG imports, to a large extent for power generation use. More recently, public financing of pricing incentives for producers - under "Plan Gas" and other programmes – has become increasingly significant.

As mentioned, earlier in 2016 the Macri administration substantially increased gas (and electricity) wholesale prices and end-user tariffs, with a view to reduce these subsidies - and reorient them towards low income segments -, but judicial injunctions have temporarily delayed this process, leaving short term uncertainty as the only foreseeable outcome at the time of the preparation of the current paper.

Figure 3.3.24 Argentina: Domestic Energy Subsidies – 2005/2014



References:
ENARSA: Gas imports.
CAMMESA: Subsidies to generators and fuel imports.
Plan Gas I & II: Subsidies to producers, for higher production than "Injection Base" adjusted by agreed declination curves.
Others: Includes LPG, natural gas, electricity and coal subsidies.
Source: Based on information from the Argentine Association of Budgeting and Public Finance Administration (ASAP).

[20] http://www.adigas.com.ar/
[21] http://www.asap.org.ar/

3.4 Natural gas and LNG: Import supply options

As discussed previously, Argentina has become a net gas importer since 2008. In 2015 the domestic supply vs. consumption gap reached 11 Bcma, which is equivalent to half of Bolivia's entire gas production.[22]

Albeit the proven gas reserves have been stable over the period 2013/2015, they remain at only 42% of the level reached in 2000. Argentina's reserves could only sustain 6.3 years at the current consumption level of 47.5 Bcma.

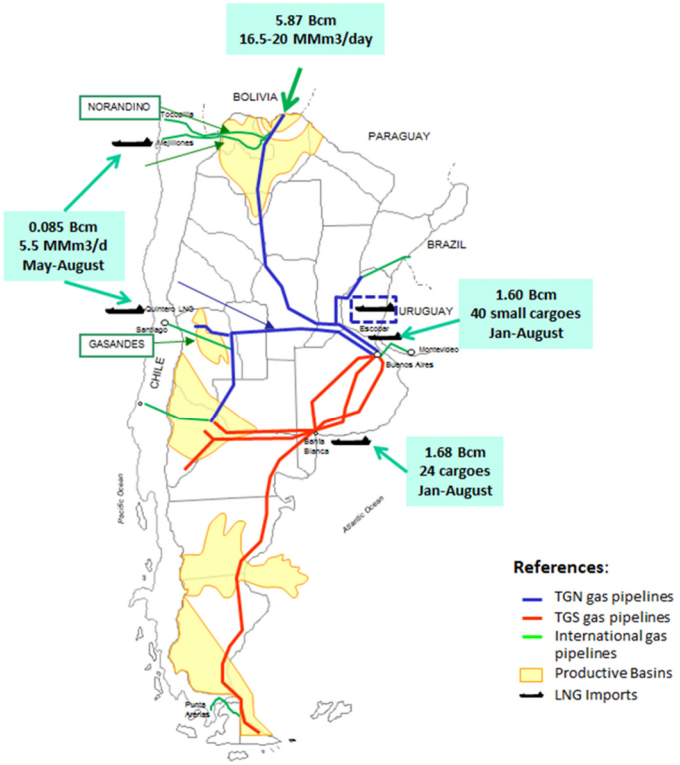
In order to fill the demand/supply gap, Argentina imports pipeline gas from Bolivia and LNG from international markets. In May 2016 Argentina started to import "pipeline gas" from Chile - which in turn, originated as Chilean LNG imports - on a seasonal basis.

As mentioned in Section 3.3, LNG is imported into Chile's regasification terminals at Quintero and Mejillones and transported via existing long distance pipelines (respectively, Gasandes and Norandino) once used to export natural gas from Argentina to Chile.

In the future Argentina will also be able to import LNG-sourced natural gas from Uruguay, via the reversible-flow pipeline Cruz del Sur, once Uruguay's Gas Sayago 263,000 m³ LNG regasification project is completed (in 2017 or 2018).

Figure 3.4.1 depicts the entry points for imported gas into Argentina and the import volumes, which by mid-2016 are expected to reach 9.24 Bcma on an annualised basis.

Figure 3.4.1 Argentina: Natural Gas Entry Points and 2016 Annualised Imports



Source: Map adapted from figure 3.3.12.
Data adapted from ENARSA, TELAM and the Argentine Ministry of Energy and Mines (MEyM), 2016.

[22] (BP, 2016)

Natural gas from Bolivia

As mentioned in Section 3.3, the 441 km Gasoducto Bolivia-Argentina (YABOG pipeline) began operating in 1972, following the development of Bolivia's gas resources and its decision to supply the more developed gas market of Argentina. The Bolivia pipeline export system also includes the 22 MMm^3/d integrated pipeline system Juana Azurduy, which connects the YABOG pipeline to Argentina's Campo Durán compression station, in the Province of Salta.

In October 2006 ENARSA and YPFB signed a Gas Supply Agreement with a term of 20 years from the start of the gas delivery volumes (2007)[23]. The Daily Contracted Quantities (DCQ) should gradually increase from 7.7 MMm^3/d in 2007 to reach a plateau of 27.7 MMm^3/d from 2010 till 2026.

Table 3.4.1 Bolivia-Argentina: Gas Supply Agreement Daily Contracted Quantities (DCQ)

Year	MMm3/d
2007	7.7
2008-2009	Up to 16
2010-2026	27.7

Source: (ENARSA, 2016)

In addition, in 2012 ENARSA and YPFB signed an Interruptible Gas Supply Agreement[24] for 15 years (until 31/12/2026), with the following DCQs:

- 2012: 2.7 MMm^3/d
- 2013: 3.3 MMm^3/d
- 2014 onwards: quantities to be defined

The above contracts have been amended in subsequent years. As of 2016, the actual contracted volumes are set at 16.4 MMm^3/d in the January-April and October-December periods, whilst in the cold period (May-September) the quantities increase to 19.3 MMm^3/d.

The imports from Bolivia are currently priced significantly below the imports of LNG. In August 2016 the price delivered at the border was 3.19 USD/MMBtu. The price is adjusted quarterly according to an indexation formula based on several liquid fuels, and has therefore fluctuated significantly - with "highs and lows" – in the last years[25].

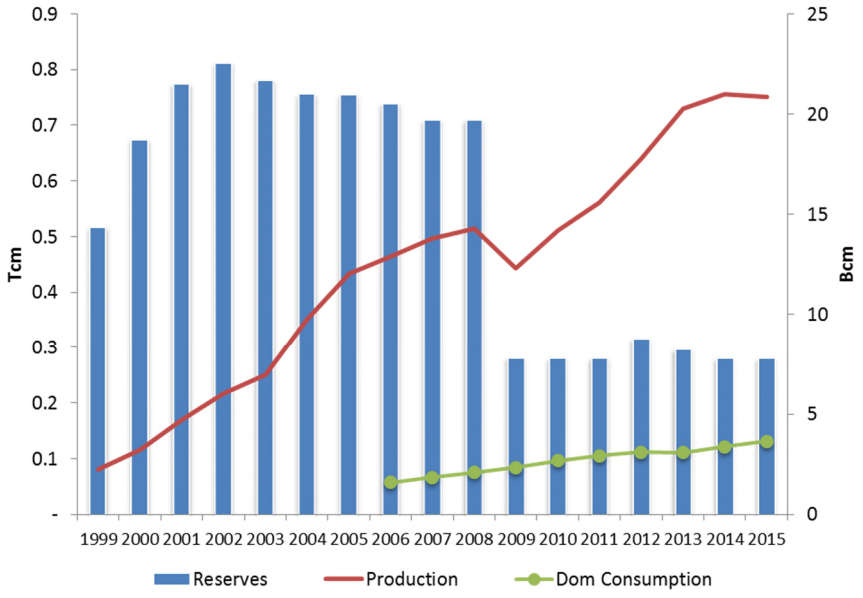
Bolivia's domestic consumption has more than doubled in the period 2006/2014, fuelled by government investment in infrastructure and very low end-user prices, ranging from 0.90 USD/MMcf for refineries and 1.3 USD/MMcf for power generation (YPFB, 2015).

Bolivia's gross production has been stable in 2014/2015, around 60-61 MMm3/d (22 Bcm), whilst marketed production has floated around 57.5 MMm3/d (20.9 Bcm) (Figure 3.4.2 and Figure 3.4.3). Proved gas reserves have dropped from 10.5 Tcf in 2014 to 9.9 Tcf in 2015, following a very significant decline in 2008 (Figure 3.4.2)[26]. In February 2016 the Bolivian Minister of Energy

[23] http://www.enarsa.com.ar/images/pdf/contrato_compra_venta_enarsa_ypfb.pdf
[24] http://hcbcdn.hidrocarburosbol.netdna-cdn.com/downloads/Contrato_YPFB-ENARSA_interrumpible.pdf
[25] http://www.enarsa.com.ar/images/pdf/contrato_compra_venta_enarsa_ypfb.pdf
[26] Proved historical reserve series as reported in the BP Statistical Review of World Energy. According to Bolivian government information the reserves had been overstated in the year 2004. See also http://eju.tv/2010/10/la-cada-de-reservas-de-gas-de-bolivia-sacude-el-mundo-petrolero-ypfb-an-no-da-cifras

announced that discoveries in the Caipipendi block could add 4 Tcf to the country's reserves, but this volume has not yet been certified[27].

Figure 3.4.2 Bolivia: Natural Gas Reserves, Production and Domestic Consumption – 1999/2015



Source: Based on Ministerio de Minas e Energía (Brazil), 2007/2016 and BP, 2016.

In addition to supplying Argentina and meeting its own growing domestic demand, Bolivia also exports natural gas to Brazil, through three gas supply agreements signed with Petrobras and totalling 30 MMm^3/d. Gas supplies to Brazil started in 1999 and the agreements will expire in 2019/2020, but they include one-year make-up periods, so in practice Bolivia is committed to supply Brazil until 2021.

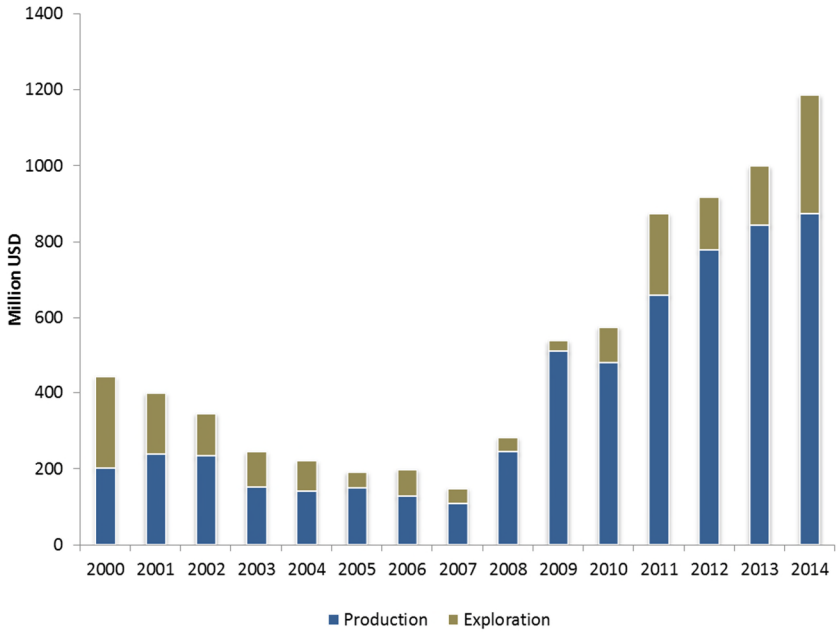
The nationalisation of the Bolivian gas industry, which started in 2004, resulted in a significant drop in exploration investment, with YPFB and private operators focusing on the development of gas production in the discoveries made in the period 1997/2002[28]. Since 2001, exploration investment has returned to – and even surpassed - 2001 levels, but the bulk of upstream investment continues to concentrate on production development (Figure 3.4.3).

The CEO of YPFB, Guillermo Acha, is keen to attract investors to help increase natural gas reserves to 18 Tcf by 2025, allowing for the depletion of existing reserves. In a company seminar organised in January 2015, YPFB stated that they need to add 7-13 Tcf to meet a demand of 1 Tcf/annum from 2025 to 2035. Since 2014 the Government of Bolivia has enacted legislation aimed at attracting foreign investment. The country needs around USD 7.5 billion of foreign investment in exploration and development from 2016 to 2020 to meet this goal.

However, potential investors face a few uncertainties: from low oil prices, to the financial difficulties faced by one of Bolivia's largest operators (Petrobras), coupled with the recession in Brazil, which impacted on the demand for natural gas in the industrial and power sectors, and the subsidised domestic prices in Bolivia.

[27] http://www.hidrocarburosbolivia.com/bolivia-mainmenu-117/upstream/72138-nuevas-reservas-de-gas-garantizan-suministro-interno-y-exportacion-por-20-anos.html
[28] http://www.cbhe.org.bo/informacion-de-la-industria/estadisticas/192-inversiones

Figure 3.4.3 Bolivia: Investment in Oil & Gas Exploration and Production – 2000/2014



Source: CNI & ABRACE, 2016 and YPFB, 2015.

At the present level of gross production (22 Bcm/year), Bolivia's proved reserves are sufficient to meet current levels of domestic demand and export volumes for 12 years, i.e., until 2027. This assumes that Argentina will continue to import only 14.5 MMm^3/d, whilst Brazil continues to import 30 MMm^3/d.

However, a recent study by the Brazilian Confederation of Industries estimates that Bolivian gross production may peak at 75 MMm^3/d in 2017-2018 and will then decline to 50 MMm^3/d in 2025. The peak production is predicated on increased output from the Incahuasi and Margarita fields.

In order to assess the future availability of Bolivian gas to Argentina, the authors developed 3 scenarios:

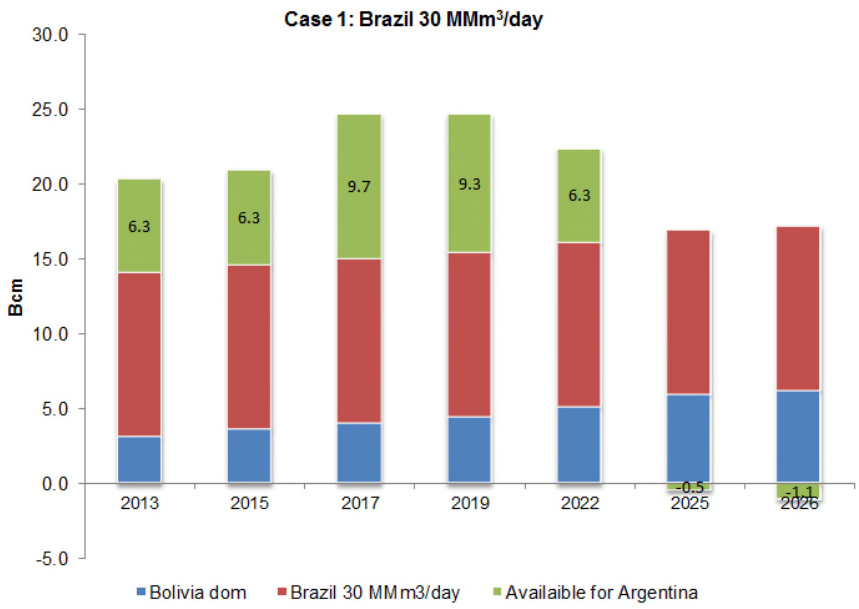
- Case 1 - Brazil continues to import 30 MMm^3/d.
- Case 2 - Brazil reduces imports to 20 MMm^3/d from 2022.
- Case 3 - Bolivia increases domestic demand and Brazil continues to import 30 MMm^3/d.

In Cases 1 and 2 it was assumed that Bolivia will not move forward with its ambitious plans to build large energy intensive industrial projects. In Case 3 Bolivia implements some of its planned large energy consuming projects (polyethylene, ammonia/urea and mining) and Brazil agrees to continue importing 30 MMm^3/d after the expiry of the gas supply agreements with Bolivia.

Bolivia established that the priority markets for its natural gas are 1) The Bolivia domestic market and 2) Brazil[29]. Argentina is thus priority number 3. If Brazil maintains its imports of 30 MMm^3/d, Bolivia could have an availability of up 9.5 Bcma for Argentina. This is predicated on the assumption of increased field production and availability of pipeline capacity, in particular on the Argentine side (Figure 3.4.4). Then in 2022 maximum gas availability for Argentina drops to 6.3 Bcma; by 2025, Bolivia would not be able to export to Argentina.

[29] The contract with Brazil precedes the contract with Argentina.

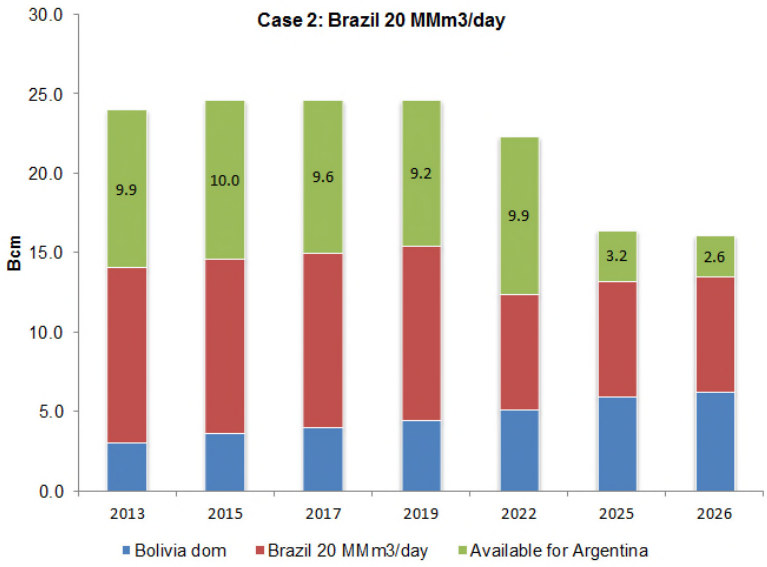
Figure 3.4.4 Bolivia: Gas Availability for Argentina / Case 1 (Low) – 2013/2026



Source: Author estimates using CNI & ABRACE, 2016, and Ministerio de Minas e Energía (Brazil), 2007/2016.

In Case 2, under which the Bolivian exports to Brazil drop to 20 MMm^3/d, the availability for Argentina can rise to 9.6 Bcma in 2022, dropping to 3.2 Bcma (8.8 MMm^3/d) in 2025 (Figure 3.4.5).

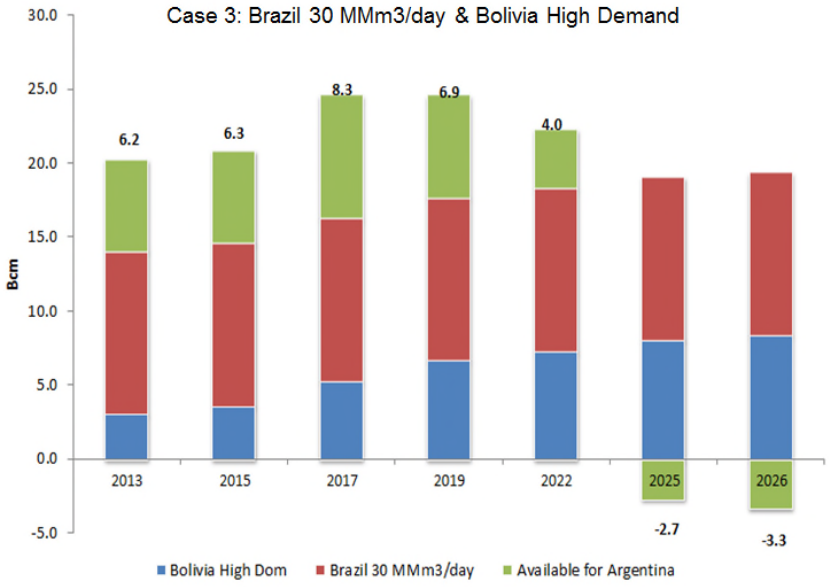
Figure 3.4.5 Bolivia: Gas Availability for Argentina / Case 2 (High) – 2013/2026



Source: Author estimates using CNI & ABRACE, 2016, and Ministerio de Minas e Energía (Brazil), 2007/2016.

In Case 3, the availability for Argentina declines to 6.9 Bcma by 2019, and afterwards Bolivia's production is not sufficient to even maintain the volumes contracted with Brazil; there is a deficit of 2.7 Bcma in 2025, widening to 3.3 Bcma by 2026 (Figure 3.4.6).

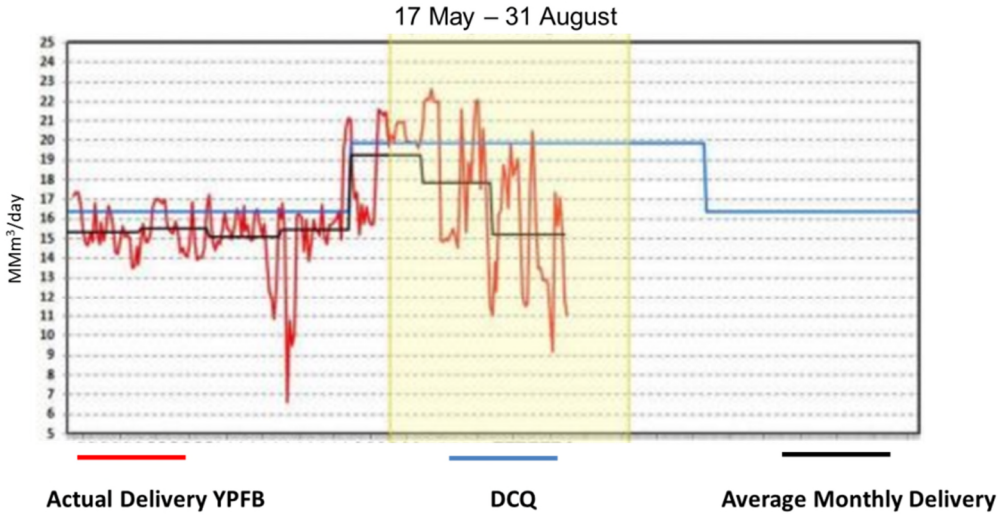
Figure 3.4.6 Bolivia: Gas Availability for Argentina / Case 3 (High Bolivia Domestic Demand) – 2013/2026



Source: Author estimates using CNI & ABRACE, 2016, YPFB, 2015 and Ministerio de Minas e Energía (Brazil), 2007/2016.

The actual situation might be worse than the above projections indicate. For example, in May 2016 the supply to Brazil dropped to 26 MMm^3/d but recovered to nearly 30 MMm^3/d in June. As a result YPFB cut the agreed supply to Argentina by 5 MMm^3/d, alleging technical and maintenance issues at the Margarita field (Figure 3.4.7).

Figure 3.4.7 Bolivia (YPFB) /Argentina (ENARSA): Contracted vs. Actual Delivery - 2016



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Also, regional experts point to the faster decline of the Petrobras-operated San Alberto field and delays in the start-up of the Incahuasi field[30]. These facts highlight the importance of LNG and of the development of unconventional gas to meet Argentina's gas demand and provide security of supply.

LNG Imports

Argentina started to import LNG in 2008, following the inauguration of the FSRU terminal of Bahia Blanca, 640 km south of Buenos Aires, and operated by Excelerate.

This was followed by the commissioning of a second FSRU in the Parana River, named GNL Escobar, and located 50 km out of Buenos Aires. The terminal started its operations in 2011, and is also operated by Excelerate. Both terminals have a send-out capacity of 500 MMcf/d, although Escobar is limited to receive smaller LNG vessels due to the problems arising from river currents. Both terminals are owned by YPF, whilst ENARSA contracts and purchases the LNG with international suppliers (since 2012, through tenders organised by YPF on behalf of ENARSA).

In 2015 Argentina imported 5.8 Bcm of LNG, representing an 11.5% decline when compared to 2014. In 2016 it is planning to import 60-65 cargoes of LNG.

Like other importing markets, Argentina benefited from the drop in LNG prices in 2015-2016. In 2015 DES prices were in excess of 7 USD/MMBtu whilst cargoes bought for August 2016 delivery were as low as 4.18 USD /MMBtu[31]. According to ENARSA, both terminals are currently operating at full capacity.

The Escobar Terminal is slated to receive 40 cargoes in 2016, with smaller parcels of 45,000 to 53,000 m^3 of liquid. The DES prices at Escobar range from 4.59 USD/MMBtu to 6.74 USD/MMBtu (Table 3.4.2).

Table 3.4.2 Argentina: LNG Deliveries Escobar Terminal – 2016

Month	Supplier	Liquid Volume (m^3)	Price DES (USD/MMBtu)
January	GNF	144,362	5.60-6.74
February	GNF	107095	5.6
March	GNF	105,600	5.6
April	GNF, Trafigura	214,313	5.05-5.60
May	GNF,Trafigura, Petrobras	320,326	4.79-5.20
June	GNF,Trafigura, Petrobras, Gazprom	428,734	4.59-5.40
July	GNF,Trafigura, Gazprom, Shell	433,544	5.15-5.67
August	GNF,Trafigura, Gazprom, Shell	379,351	4.88-5.36
Total		1,753,974	

Source: (ENARSA, 2016)

The Bahía Blanca Terminal is expected to receive 24 LNG cargoes in 2016, with prices varying from 4.18 USD/MMBtu to 12.593 USD/MMBtu. The suppliers range from traditional players such as BP

[30] http://eju.tv/2016/05/gas-bolivia-cumple-no-cumple-argentina/
[31] http://revistapetroquimica.com/por-la-crisis-del-crudo-ypf-paga-un-35-menos-por-el-lng-importado/

and Shell, to pure traders such as Vitol, Trafigura and Glencore. It is worth noting that Cheniere is expected to deliver its first cargo to Argentina in August 2016[32].

Table 3.4.3 Argentina: LNG Deliveries Bahía Blanca Terminal - 2016

Month	Supplier	Liquid Volume (m^3)	Price DES (USD/MMBtu)
January	BP	86,189	12.593
February	None	0	0
March	BP	78,346	5.64
April	BP	75,508	4.68
May	BP, Koch, Glencore, Trafigura, Statoil	426,822	4.37-4.53
June	BP, Gazprom, Trafigura,	421,732	4.18-4.71
July	Shell, Vitol, Gazprom, Eni	503,994	4.65-5.15
August	Vitol, Shell, Gazprom, Cheniere	419,995	4.63-5.07
Total		2,012,586	

Source: (ENARSA, 2016)

LNG-originated imports from Chile

In early 2016, the Argentine Ministry of Energy and Mines (MEyM) started negotiations with the Chilean Government to import 362 MMm^3 (5.5 MMm^3/d) of regasified LNG and 200 MW of electricity during the winter period. Chile would export gas to Argentina via the Gasandes and Norandino pipelines, transporting regasified LNG originated at the terminals of Quintero in central Chile and Mejillones in the north.

The Chilean government also committed to invest USD 200 million in the development of the upstream incremental Project Area Magallanes (southern Argentina), jointly operated by Chilean oil company ENAP and (its affiliate) Sipetrol and Argentina's YPF.

A key reason for importing regasified LNG from Chile lies in YPFB failing to deliver up to 1.0 MMm^3/d in summer and up to 5.0 MMm^3/d in winter of contracted gas volumes. The Argentine Ministry of Energy and Mines has been publishing a chart comparing actual deliveries versus the YPFB DCQ on a weekly basis.

In April 2016, ENARSA received an offer from SOLGAS, a subsidiary of ENGIE (formerly GdF Suez) to receive regasified LNG imported at the Mejillones terminal in north Chile and transported to the Argentine province of Salta via the Norandino pipeline. Gas flows started in mid-May 2016[33].

According to Argentina's media, the deal with SOLGAS encompasses the supply of 86 MMm^3 delivered at the Argentina border during a 3-month period, from mid-May to mid-August 2016.

Under the agreement signed with Chile's national oil company ENAP[34], ENARSA will import a total of 276 MMm^3 from May 17 to August 31 2016. LNG will be imported at the Quintero LNG Terminal in Chile and transported to Argentina via the Gasandes pipeline.

[32] http://www.enarsa.com.ar/index.php/es/comunicadosenarsa/570-impotacion-gnl
[33] http://www.lapoliticaonline.com/nota/97491/
[34] http://www.lanacion.com.ar/1923797-radiografia-del-gas-en-la-argentina-de-donde-viene-que-cantidad-y-cuanto-se-gasta

The price of regasified LNG from Chile ranges from 6.90 to 7.20 USD/MMBtu. The price includes Chilean's excise duty of 6%. Argentina's media mention that the volumes are paid in advance, on a monthly basis.

The Chile import price compares unfavourably to the August 2016 prices of 3.19 USD/MMBtu paid to Bolivia and the latest import price paid by ENARSA for a cargo of LNG, 4.18 USD/MMBtu DES, to which one should add the regasification costs of 0.8-1.1 USD/MMBtu. But it compares favourably with the cost of diesel, around 9.7-10.4 USD/MMBtu, according to energy consultants in Argentina[35].

3.5 Unconventional oil and gas exploration and production: Current status

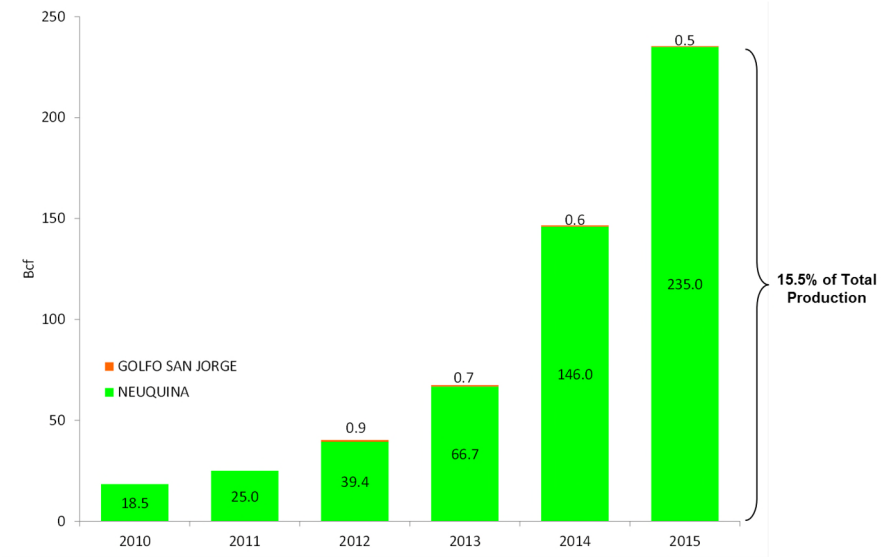
According to the US Energy Information Administration (EIA), there are only four countries currently producing commercial volumes of shale gas and oil: the USA, Canada, Argentina and China.[36]

Argentina produces both shale oil, and gas and significant commercial volumes of tight sands gas. The operators in the Neuquén basin have successfully reversed the decline in conventional gas production by developing tight sands gas reservoirs. The initial activity for shale resources was mainly focused on the Vaca Muerta formation.

The Neuquén basin, which is located in west-central Argentina, is the epicentre for both shale and tight sands gas activities. It is worth noting that conventional petroleum activities in this basin began in 1918 with circa 20,000 oil and gas wells drilled by 2015[37].

Unconventional gas production reached 235.5 Bcf (6.7 Bcm) in 2015 and accounted for 15.5% of Argentina's total gas production in the year (Figure 3.5.1). Cumulative gross production in the period 2010/2015 totalled 533 Bcf (15.1 Bcm). Nearly all of Argentina's unconventional gas production arises from Neuquén, with some activities also taking place in the Golfo San Jorge basin, in the south of the country.

Figure 3.5.1 Argentina: Unconventional Natural Gas Gross Production by Basin - 2010/2015 (1) (Bcf)

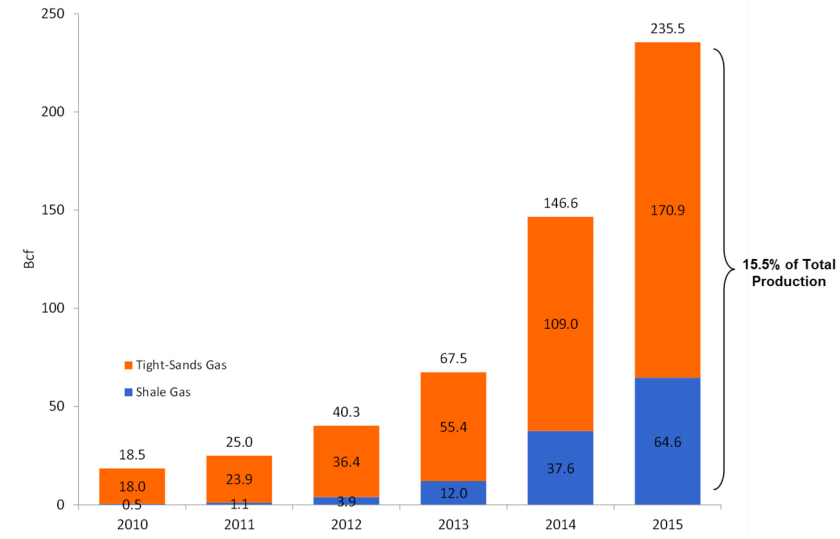


Reference: (1) Cumulative gross production 2010/2015: 533 Bcf (15.1 Billion m³)
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

[35] http://www.ieco.clarin.com/Argentina-empieza-importar-natural-Chile_0_1572442791.html
[36] http://www.eia.gov/todayinenergy/detail.cfm?id=21832
[37] http://www.iapghouston.org/files/articles/2013-1_1.pdf

The production of tight sands gas is currently equivalent to nearly three times the production of shale gas (Figure 3.5.2), but tight sands gas development started much earlier, in the year 2009, as a consequence of the gas pricing incentive plan “Gas Plus”, enacted in 2008.

Figure 3.5.2 Argentina: Unconventional Natural Gas Gross Production by Type of Reservoir - 2010/2015 (1) (Bcf)

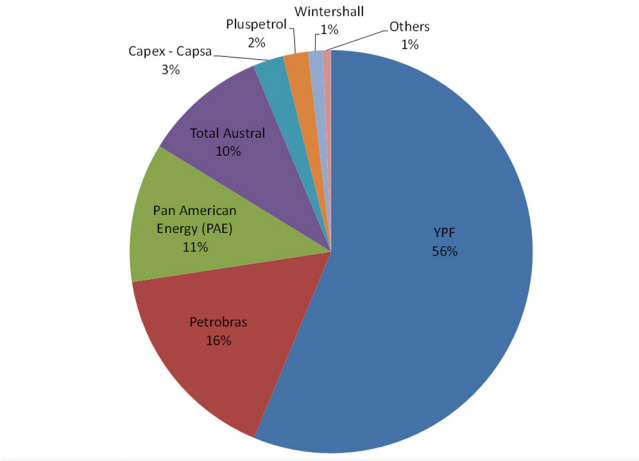


Reference: (1) Cumulative gross production 2010/2015: 533 Bcf (15.1 Billion m³)
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

YPF (the national oil company), Pan American Energy (a BP/Bridas joint-venture) and Petrobras have been heavily involved in the development of tight sands gas projects in Neuquén, whereas the shale oil and gas activity started later, with YPF taking the lead in partnership with international and national oil companies.

International oil companies hold upstream leases and are engaged in drilling in shale and tight sands gas formations, mostly in partnership with YPF, which is currently responsible for 56% of the production of unconventional gas in Argentina, followed by Petrobras (16%) and Pan American Energy with 11% (Figure 3.5.3).

Figure 3.5.3 Argentina: Unconventional Natural Gas Gross Production by Operator – 2015 (Bcf)

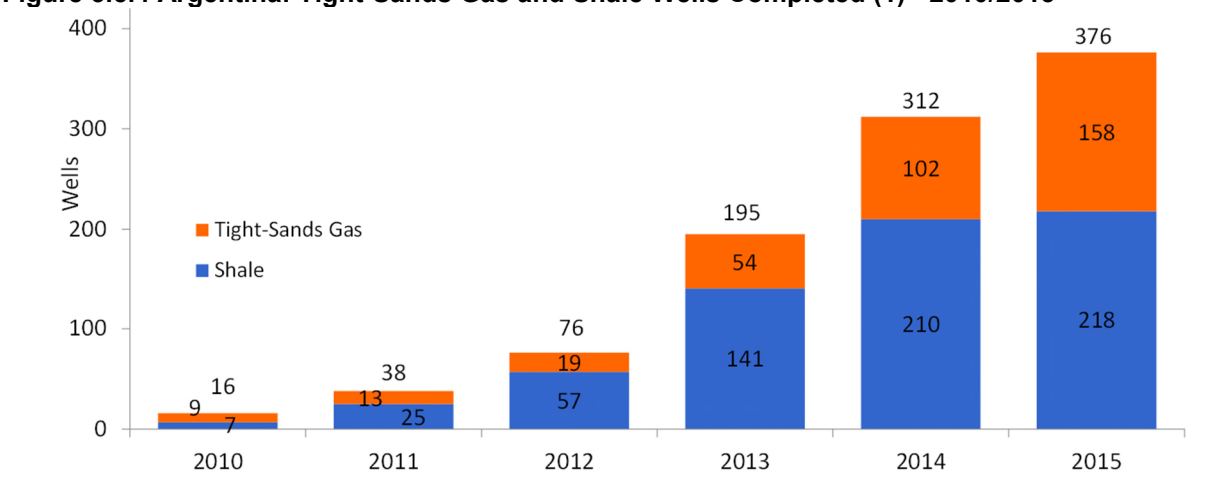


Total Gross Production: 235.5 Bcf (6.7 Billion m3)

Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

By year-end 2015 the cumulative number of completed unconventional gas and oil wells in Argentina reached 1,101, of which 673 are shale (gas and oil) and 428 are tight-sand wells. In 2015 alone the operators drilled 376 new wells, of which 218 were shale and 158 were tight-sand wells. (Gobierno de la Provincia de Neuquén, 2015) (Figure 3.5.4).

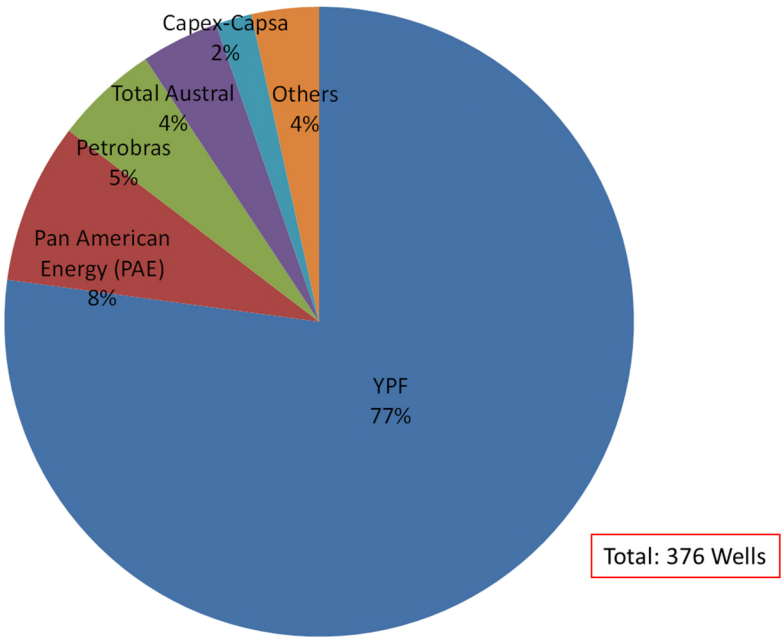
Figure 3.5.4 Argentina: Tight-Sands Gas and Shale Wells Completed (1) - 2010/2015



References: (1) Cumulative wells completed since 2006:1,101 (673 Shale and 428 Tight-Sands Gas).
Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

YPF has been responsible for 2/3 of the cumulative number of unconventional wells drilled in Argentina, followed in a distant second place by Petrobras, with around 90 wells. Pan American Energy, Capex-Capsa and Total drilled circa 55 wells each. Figure 3.5.5 shows the wells drilled by operator in 2015.

Figure 3.5.5 Argentina: Tight-Sands Gas and Shale Wells Completed, by Operator – 2015



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Tight-sands gas

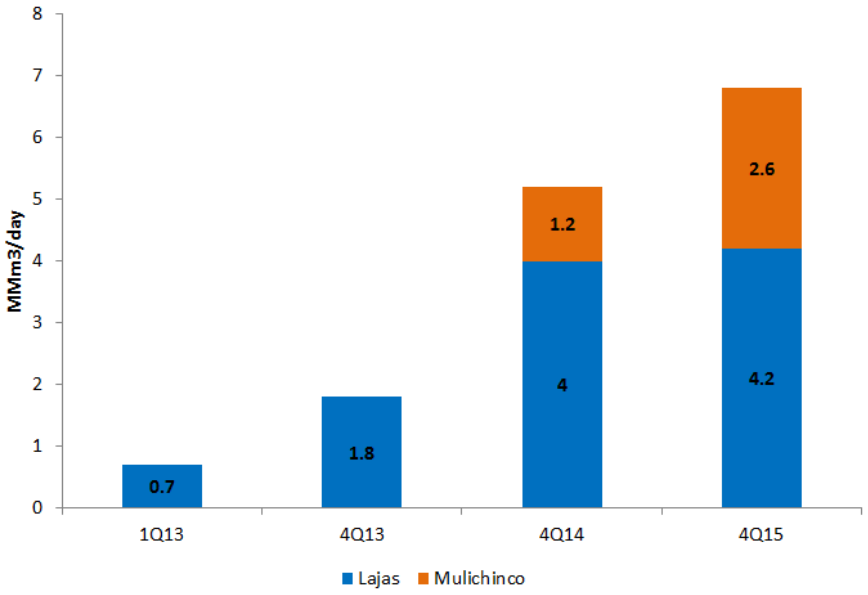
The tight sands gas producing reservoirs in the Neuquén basin are located in the mid-west area of the province. They include the formations Los Molles, Lajas, Punta Rosada, Precuyo (Lotena, Tordillo, Sierras Blancas) and Mulinchico. There are 16 tight sands gas producing areas, of which Loma La Lata, Rincón del Mangrullo, Lindero Atravesado and El Mangrullo account for 70.6% of the gas produced in the province.

Tight sands gas production in December 2015 reached 14.4 MMm^3/d. According to information provided on the Wood Mackenzie website, tight sands gas production continues to ramp up, reaching 16 MMm^3/d in the first quarter of 2016 and accounting for 25% of Neuquén's total gas production[38].

YPF's recent progress in developing the Mulichinco and Lajas formations has seen production treble in a period of just two years (Figure 3.5.6).

According to Wood Mackenzie, well performance has been very variable in Neuquén; out of six plays studied the median 90-day initial production rate (IP-90) was 56,000 m^3/d, whilst the lower and upper quartile performed respectively at 23,000 and 116,000 m^3/d[39].

Figure 3.5.6 Neuquén (Argentina): Tight-Sands Development by YPF – Lajas and Mulichinco formations



Source: YPF (2015)

Other operators are also producing from tight sand formations, including Pan American Energy, Petrobras, Total, Pluspetrol and Wintershall.

[38] http://www.woodmac.com/media-centre/12533060
[39] (Wood Mackenzie, 2016)

Shale oil and gas

The main sedimentary basins where shale formations occur in Argentina are[40]:

- Neuquén basin: This is the main focus of shale exploration in the country, with two good potential areas, Los Molles (Jurassic) and Vaca Muerta.
- Golfo San Jorge basin: Located in the Patagonian region, with focus in the Province of Chubut.
- Austral basin: Located in southern Argentina
- Chaco-Paranaense basin: Located in northeast Argentina

The 2015 update of the shale gas study sponsored by the EIA and prepared by Advance Resources International (ARI) highlights that Vaca Muerta - in the Neuquén basin - and L. Inoceramus-Magnas Verde - in the Austral basin - hold 84% of the technically recoverable shale resources in Argentina. Vaca Muerta is advantaged for holding a substantial reserve of tight oil, in addition to shale gas (Table 3.5.1).

Table 3.5.1 Argentina: Shale Oil and Gas Technically Recoverable Resources, by Basin

Basin	Formation	Risked Gas in Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil in Place (Billion bbl)	Technically Recoverable (Billion bbl)
Neuquén	Los Molles	275	61	3.7	3.7
	Vaca Muerta	308	270	16.2	16.2
San Jorge	Aguada Bandera	51	0	0	0
	Pozo D-129	35	17	0.5	0.5
Austral Magallanes	L. Inoceramus	129	131	6.6	6.6
Chaco Paranaense	Ponta Grossa	3	0	0	0

Source: (EIA, 2015)

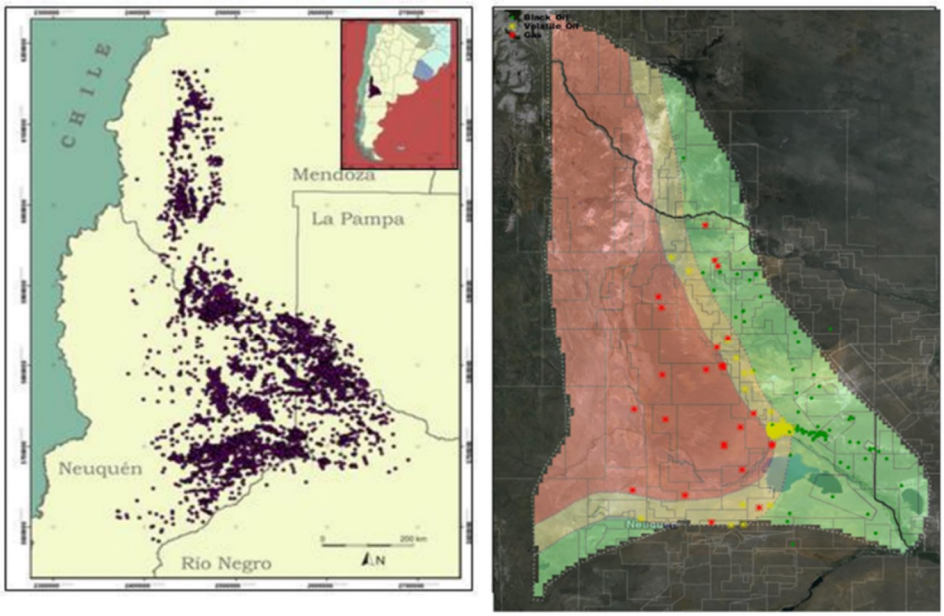
Vaca Muerta

The Vaca Muerta formation is the primary source rock for hydrocarbons in the Neuquén basin. Vaca Muerta extends over an area of 36,000 km^2. The map in Figure 3.5.7 provides an overview of the areas with tight oil, wet and dry gas formations in the Neuquén basin.

The eastern and southern regions in the basin have potential for oil production (green); the western region is predominately dry gas (red) whereas the area in yellow contains wet gas and condensate.

[40] (EIA, 2015)

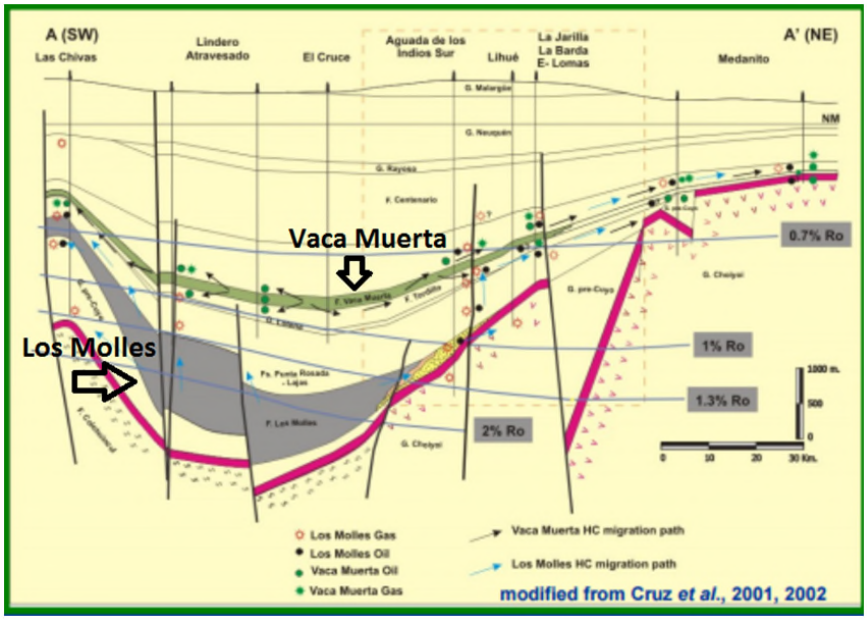
Figure 3.5.7 Neuquén Basin (Argentina): Shale Oil and Gas Formations



Source: Argentine Ministry of Energy and Mines (MEyM) and (IAPG Houston) 2015)

The Los Molles shale formation occurs at depths of 2,400 to 4,400 m whereas Vaca Muerta occurs from the outcrop up to 2,700 m depth (Figure 3.5.8). According to the EIA assessment, Vaca Muerta is generally richer in Total Organic Content (TOC) than Los Molles, with a larger potential distribution of wet gas and tight oil. Vaca Muerta is also very thick, with 350 metres in the northern part of Neuquén, and an average of 200 metres.

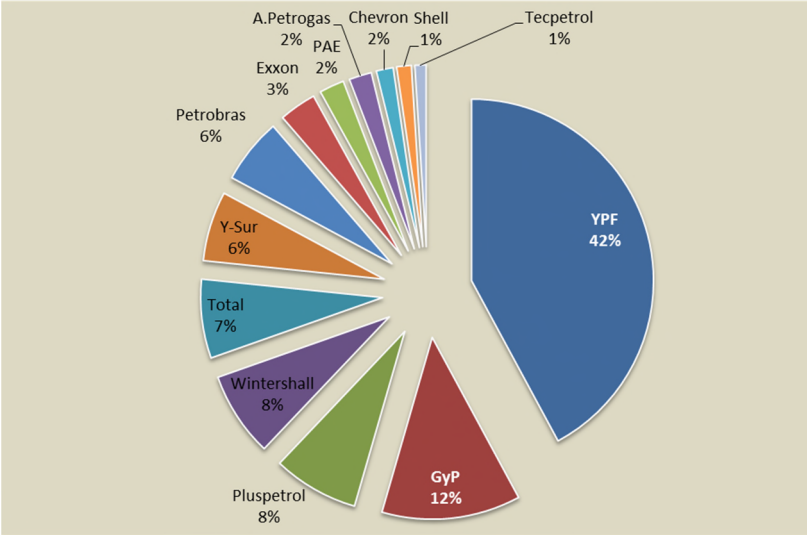
Figure 3.5.8 Neuquén Basin (Argentina) Cross Section: Vaca Muerta and Los Molles Shale Formations



Source: Mosquera, 2009.

YPF holds 42% of the acreage in Vaca Muerta, followed by Gas y Petróleo del Neuquén (GyP) a company formed in 2008 and controlled by the provincial government (Figure 3.5.9). YPF is the predominant player in Vaca Muerta, but there are another 12 international and domestic companies with concessions in the area. Some are in partnership with YPF or GyP, and others are investing independently.

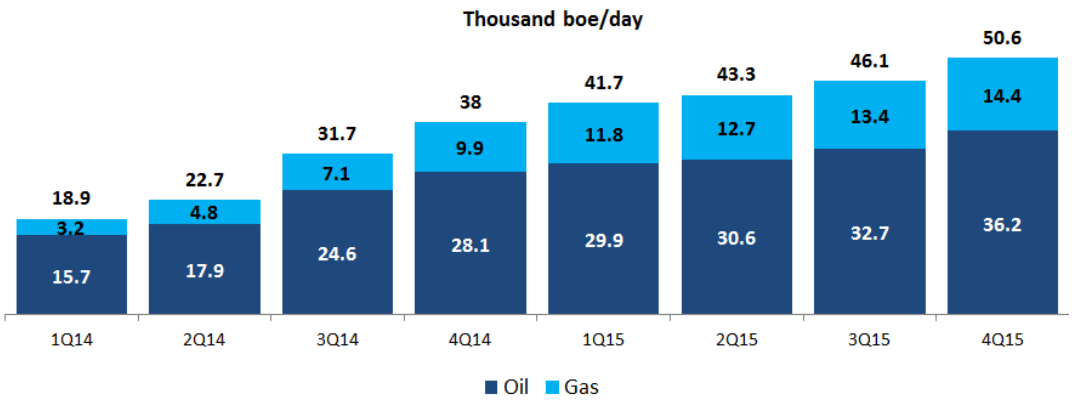
Figure 3.5.9 Vaca Muerta (Neuquén/Argentina): Acreage Distribution by Company - 2015



Source: Rebossio, 2015.

According to YPF, at the end of 2015 the gross production from YPF operated Vaca Muerta pilots and development projects (Loma Campana, El Orejano, Bandurria and La Amarga Chica) reached 50,600 boe/d[41] (Figure 3.5.10)

Figure 3.5.10 Vaca Muerta (Neuquén/Argentina): YPF Gross Shale Oil and Gas Production (1)- 2014/2015



References: (1) Total operated production (Loma Campana + El Orejano + Bandurria + La Amarga Chica).
Source: YPF, 2016.

[41] Of which 36,200 bbl/d was oil and 14,400 boe/d was gas.

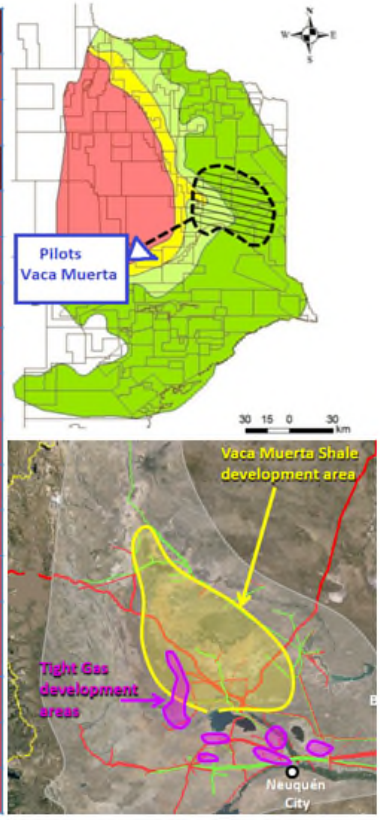
The Loma Campana project, operated by YPF in partnership with Chevron, accounts for 89% of the oil output in 2015, followed by Sierras Blancas (3%). Loma Campana[42] also accounts for 59% of the unconventional gas production in the province, followed by El Orejano (21%) and Aguada Pichana (14%)[43].

Investment update

There are at least 15 main shale gas projects in the Vaca Muerta area; 13 are either in very early stages or pilot schemes whilst 2 are already under development, Loma Campana (LC) and El Orejano, which is in a less advanced stage when compared to LC (Figure 3.5.11).

Figure 3.5.11 Vaca Muerta (Neuquén/Argentina): Main Pilot and Development Projects

Development	
Loma Campana (oil)	YPF/Chevron
El Orejano (gas)	YPF/Dow
Pilots	
La Amarga Chica	YPF/Petronas
Bajada de Añelo	YPF/YSur
Bandurria Norte	Wintershall
Bandurria Centro	PAE/YPF
Bandurria Sur	YPF
Cruz de Lorena	GyP/Shell
Sierras Blancas (oil)	GyP/Shell/Medanito
La Invernada/Bajo el Choique (oil)	GyP/Exxon
Aguada Federal (oil)	GyP/Wintershall
La Escalonada/Rincón de la Ceniza (gas and condensates)	GyP/Total/Shell
Aguada Pinchana (dry gas)	Total
Fortín de Piedra	Tecpetrol
Los Toldos	Tecpetrol/Exxon/GyP



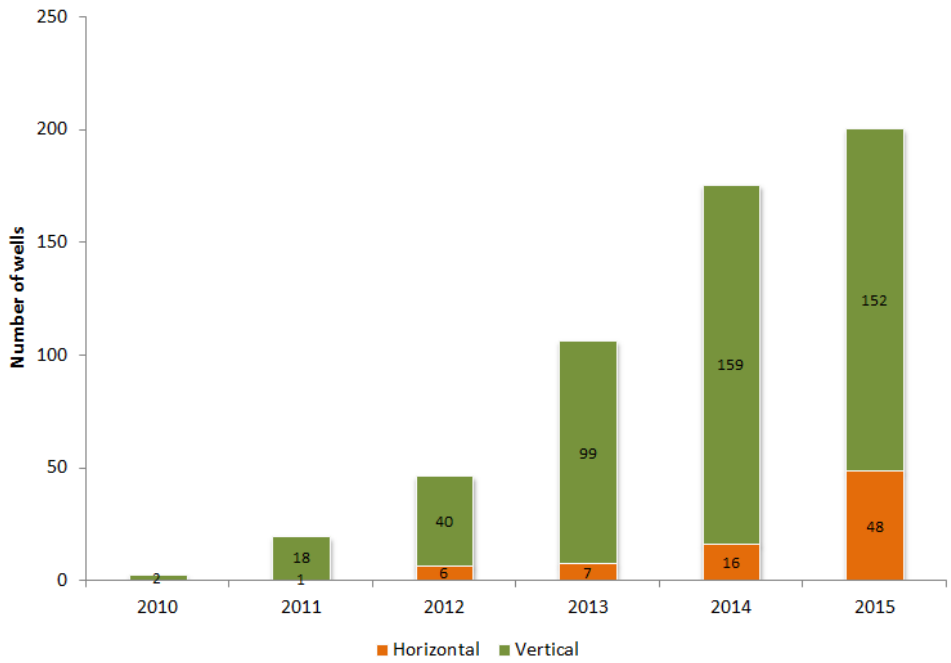
Source: Adapted from 2015 annual report, Neuquén Province Government and Spies, 2016.

Until recently, most of the shale activity focused on the oil prone zone. The largest development project, Loma Campana, is located in the oil zone and is strategically located near under-utilised facilities of one of Argentina's largest gas producing fields, Loma La Lata. Loma Campana is also conveniently located in relation to water sources and road infrastructure. More recently the drop in international oil prices, coupled with attractive domestic producer prices and the gas shortage in Argentina, have encouraged producers to ramp-up projects in the gas prone area.

By the end of January 2016 there were 588 wells completed on Vaca Muerta[44] (Figure 3.5.12). In 2015 alone the operators drilled around 200 wells in Vaca Muerta, 173 of which were completed by YPF and its partners. YPF and its partners also completed 77 tight sands gas wells in the same year.

[42] Loma Campana produces oil and associated gas; El Orejano and Aguada Pichana produce dry gas.
[43] (Gobierno de la Provincia de Neuquén, 2015)
[44] (Total, 2016), (Spies, 2016)

Figure 3.5.12 Vaca Muerta (Neuquén/Argentina): Shale Oil and Gas Wells Drilled – 2010/2015



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

The first well using hydraulic fracturing was brought into production in late 2010 whereas the early development of the area started in 2013, with the drilling of 100 wells.

YPF's strategy was initially focused on developing Vaca Muerta by drilling vertical wells, apparently due to their views on the vertical heterogeneity and pay thickness of the play[45]. Horizontal drilling by YPF only began in 2014 with the drilling of 4 wells; in 2015 it accounted for 24% of the wells drilled in Loma Campana totalling 30 horizontal wells. According to YPF Q1 2016 Results[46] , in the first quarter of 2016 the company drilled 23 horizontal wells out of a total of 34.

YPF and the other operators have been steadily working to reduce drilling and completion costs. According to YPF it cost circa USD 11 million to drill and complete a vertical well in 2011 in about 43 days; in 2014 it cost about USD 7.6 million in about 25 days, with 46% of the total cost relating to drilling and 35% to completion.

One of the independent operators mentioned that the cost of drilling seven horizontal wells was expected to reach USD 165 million, i.e. USD 23 million/well[47].

By comparison, the cost to drill and complete an onshore oil and natural gas well in the US (2015) ranges from USD 5.2 million to USD 7.2 million, according to a study commissioned by the US Energy Information Administration and produced by IHS (Table 3.5.2).

[45] According to industry sources, this was seen as the fastest way to increase production, taking into account the higher availability of vertical rigs, local experience in vertical drilling and the complexity of Vaca Muerta (calcite veins and higher clay content zones)
[46] (YPF, 2016)
[47] Comments from independent operator

Table 3.5.2 USA: Evolution of Onshore Drilling Costs – Combined Horizontal and Vertical Wells - 2014/2015

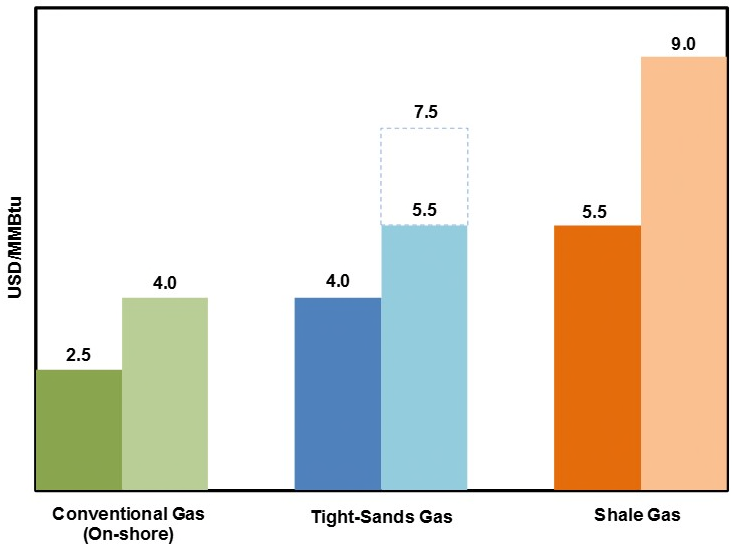
Formation	Well Cost (USD million)	
	2014	2015
Bakken	7.1	5.9
Eagle Ford	7.6	6.5
Marcellus	6.6	6.1
Midland Basin (Permian)	7.7	7.2
Delaware Basin (Permian)	6.6	5.2

Source: (EIA, 2016)

Industry analysts estimate that the cost of a vertical well in Argentina has dropped to USD 7-8 million by the end of 2015. There is some discrepancy in public information about the cost of horizontal wells, with YPF mentioning USD 13-14 million[48] whereas a report from Macquarie estimates costs of USD 11-17 million per horizontal well[49]. YPF is working with its partners with the declared objective of reducing the cost of horizontal wells to USD 10 million by the end of 2016, which is quite ambitious in light of the current labour and logistic costs.

Taking into account current costs and outputs, the authors estimate that shale gas in Argentina is likely to cost twice as much as conventional gas, ranging from 5.5-9.0 USD/MMBtu against conventional gas at 2.5-4.0 USD/MMBtu, whereas - in most cases - tight sands gas production costs range from 4.0 to 5.5 USD/MMBtu (Figure 3.5.13). It is worth noting that a recent news release from Wood Mackenzie[50] estimates that the most expensive tight sands gas wells in the basin (Mulichinco horizontal and Punta Rosada vertical wells) break even at or below the government incentivised gas price of 7.50 USD/MMBtu.

Figure 3.5.13 Argentina: Domestic Gas Production Cost Range by Main Technologies, in August 2016

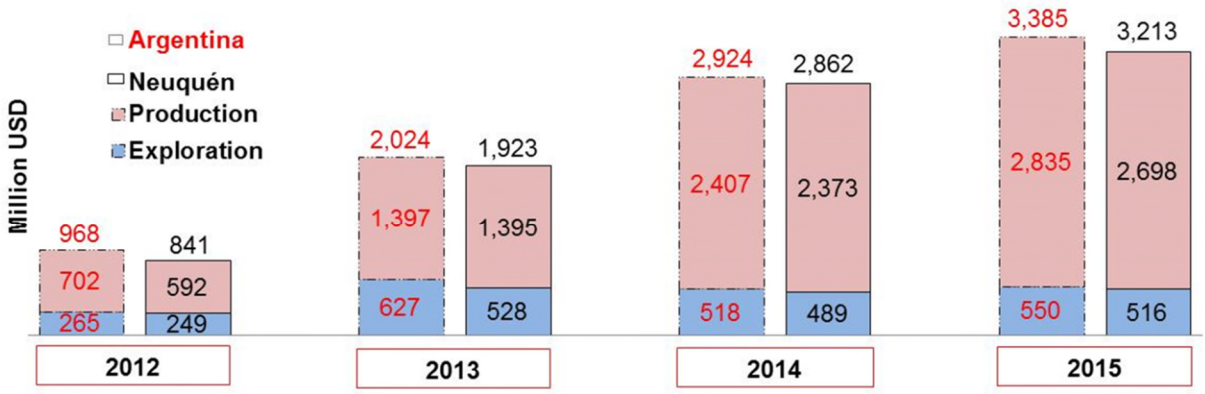


Source: Author estimates, based on industry consultation and Wood Mackenzie.

[48] http://www.rigzone.com/news/oil_gas/a/138154/Argentinas_YPF_Sees_Cost_Of_Vaca_Muerta_Drilling_Falling_10
[49] http://andesenergiaplc.com.ar/wp-content/uploads/2012/08/Macquarie-Research-AEN-Lowering-our-horinzontal-well-cost-assumptions-for-Vaca-Muerta.pdf
[50] (Wood Mackenzie, 2016)

According to the Ministry of Energy and Mines (MEyM), the accumulated investment in unconventional oil and gas exploration and production in the 2012/2015 period totalled USD 9.3 billion, of which 18% (USD 1.7 billion) was in exploration activities. As discussed previously, Neuquén accounts for most of the investment, circa USD 8.87 billion in the same period (Figure 3.5.14).

Figure 3.5.14 Argentina: Unconventional Oil and Gas Exploration and Production Investments – 2012/2015 (Million USD)



Source: Based on information from the Argentine Ministry of Energy and Mines (MEyM).

Narrowing the focus to Vaca Muerta Table 3.5.3 summarises the gross investment in 2015 related to the three main shale projects operated by YPF (Loma Campana, El Orejano and La Amarga Chica) and the ongoing tight sands gas project in Rincón del Mangrullo totalling USD 2.6 billion, an increase of 10% vis-a-vis 2014.

Table 3.5.3 YPF Operated Tight-sands Gas and Shale Projects: Gross CAPEX and Completed Wells – 2014/2015

	CAPEX (USD million)		Completed wells	
	2014	2015	2014	2015
Shale oil & gas	1790	1990	163	173
Tight sands gas	580	610	77	77
Total	2370	2600	240	250

Source: Information provided by YPF to the authors.

The Loma Campana (YPF/Chevron JV) CAPEX investment in 2015 totalled USD 1.4 billion, accounting for 75% of YPF's operated assets investment in the year.

Over the last three years, the oil and gas companies operating in Argentina have announced a sequence of farm-ins, acquisitions and organic investment on Vaca Muerta shale gas and oil projects, summarised below.

July 2013	Chevron acquires a working interest of 50% from YPF in Loma Campana – a 100-wells programme estimated at USD 1.2 billion.
September 2013	Dow Chemical acquires 50% of the El Orejano block from YPF funding a USD 120 million, 6 shale gas wells. YPF will fund part of the programme investing USD 68 million.
September 2013	Wintershall acquires 50% in the Aguada Federal block from GyP, funding 6 delineation wells over a 2-year period.
October 2013	Total launches a USD 300 million pilot project on Aguada Pichana, aiming to lay 20 development wells and produce 4 MMm^3/d of natural gas.
February 2014	YPF farms-out 1,240 km^2 of Vaca Muerta shale acreage to Pluspetrol, which was part of the 10 blocks previously held by the Argentine operations of Apache. Pluspetrol paid USD 217 million and will form a 50/50% partnership with YPF to develop pilot projects on seven blocks.
April 2014	Chevron and YPF agree on a 170 wells development, estimated at USD 1.6 billion.
April 2014	Shell acquires from Total a 42.5% participation in 2 blocks (La Escalonada and Rincón de las Cenizas) allowing for the funding of USD 250-300 million, for the acquisition of 3D seismic, drilling of horizontal wells and new facilities. GyP holds 15% of each block.
August 2014	Petronas acquires from YPF a 50% interest on the block La Amarga Chica, allowing for the funding of USD 475 million for a 30-well pilot development programme.
June 2015	Tecpetrol pays USD 63 million to acquire the shares of the Argentine subsidiary of the Canadian company Americas Petrogas which holds participations in three blocks in Neuquén - Loma Ranqueles (unconventional gas), Los Toldos (unconventional gas and oil) and Huacalera (unconventional gas), and two blocks in La Pampa - Medanito Sur and Rinconada Norte (conventional)[51]. Subject to project viability, Tecpetrol plans to invest USD 1.5 billion by 2020 to drill and complete 120 wells, in addition to USD 200 million to drill and complete 5 shale pilot wells on Fortin de Piedra.[52.]
August 2015	Shell is awarded the lease of the Sierras Blancas and Cruz de Lorena blocks in the Vaca Muerta area, with announced plans to invest USD 250 million.
December 2015	YPF and Dow agree to invest another USD 500 million to drill 30 more wells on the El Orejano shale project, with a view to increase production to 2 MMm^3/d[53].
January 2016	YPF and American Energy Partners, LP (AELP) sign preliminary agreements with the aim of investing USD 500 million in the development of shale gas projects, including a pilot scheme in the Bajada de Añelo block, and developing a smaller area in Vaca Muerta Cerro Arena[54].

[51] (Macellari, 2016), (Wintershall, 2016), (Argentina Shale, 2016)
[52] (Macellari, 2016), (Wintershall, 2016), (Argentina Shale, 2016)
[53] http://www.infobae.com/2015/12/15/1776662-mauricio-macri-anuncio-millonaria-inversion-vaca-muerta-junto-miguel-galuccio/
[54] The project has not moved ahead in the wake of the death of AELP's CEO.

June 2016	Exxon announces USD 250 million investments for a pilot project in the “coming months”, in addition to USD 200 million already spent in exploration on the Bajo del Choique-La Invernada block.
July 2016	Pan American Energy announces plans to invest USD 1.4 billion in gas and oil projects in Argentina, of which USD 300 million on shale gas projects in Neuquén:

Also in January and April 2015, YPF signed preliminary agreements with - respectively - Sinopec and Gazprom, for future cooperation in both conventional and unconventional oil and gas development.

4. Natural gas demand and supply outlook for 2016/2030

In order to place unconventional gas development in perspective, it is necessary to analyse the long term prospects of the Argentine gas market.

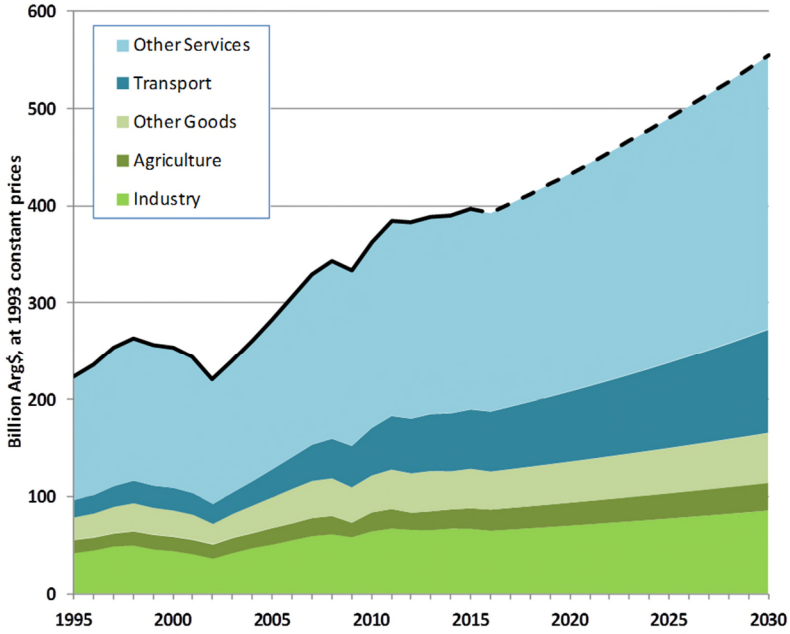
For this purpose, this section will make reference to two alternative scenarios of a recent 2016/2030 forecast performed by the authors, through use of a proprietary Energy Balance Simulation Model. The two selected scenarios are: a) "Business as Usual" and b) "Renewables and Energy Efficiency".

4.1 Key assumptions

The above-mentioned forecast included the following key assumptions:

- Gross Domestic Product (GDP): 2.5% compound annual growth rate (CAGR) for 2017/2030 (following an estimated fall of 1.0%, in 2016), as shown in Figure 4.1.1.

Figure 4.1.1 Argentina: Gross Domestic Product Forecast – 2016 / 2030



Year	%cagr
2015	1.5%
2016	-1.0%
2017	2.5%
2018	2.5%
2019	2.5%
2020	2.5%
2021	2.5%
2022	2.5%
2023	2.5%
2024	2.5%
2025	2.5%
2026	2.5%
2027	2.5%
2028	2.5%
2029	2.5%
2030	2.5%

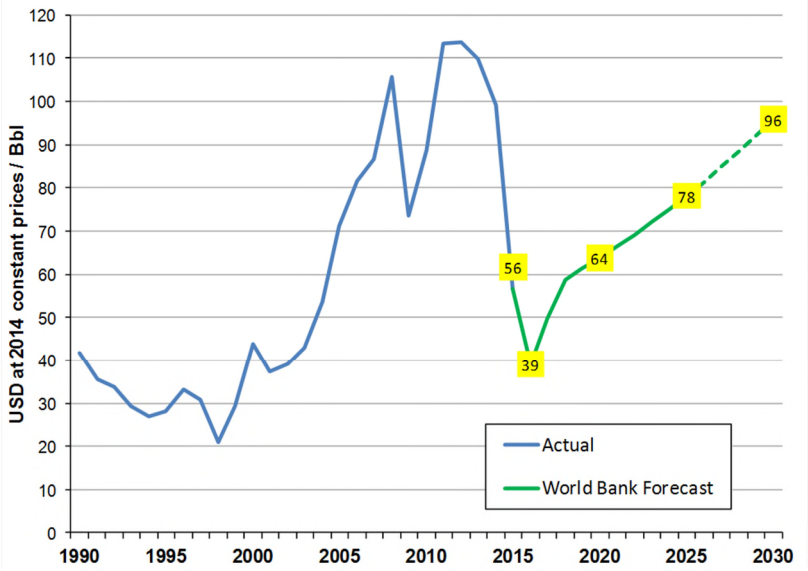
2014/2030: 2.2%cagr

Source: Author estimates, for forecasting exercise.

- Brent crude oil price: Recent World Bank estimates were used for 2016/2025[55], and extrapolated to 2030 (see Figure 4.1.2). The forecast assumes a gradual recovery of Brent quotations as of 2017, reaching 64 USD/barrel (at 2014 constant prices) in 2020.

[55] See http://www.worldbank.org/en/publication/global-economic-prospects and http://www.worldbank.org/en/research/commodity-markets

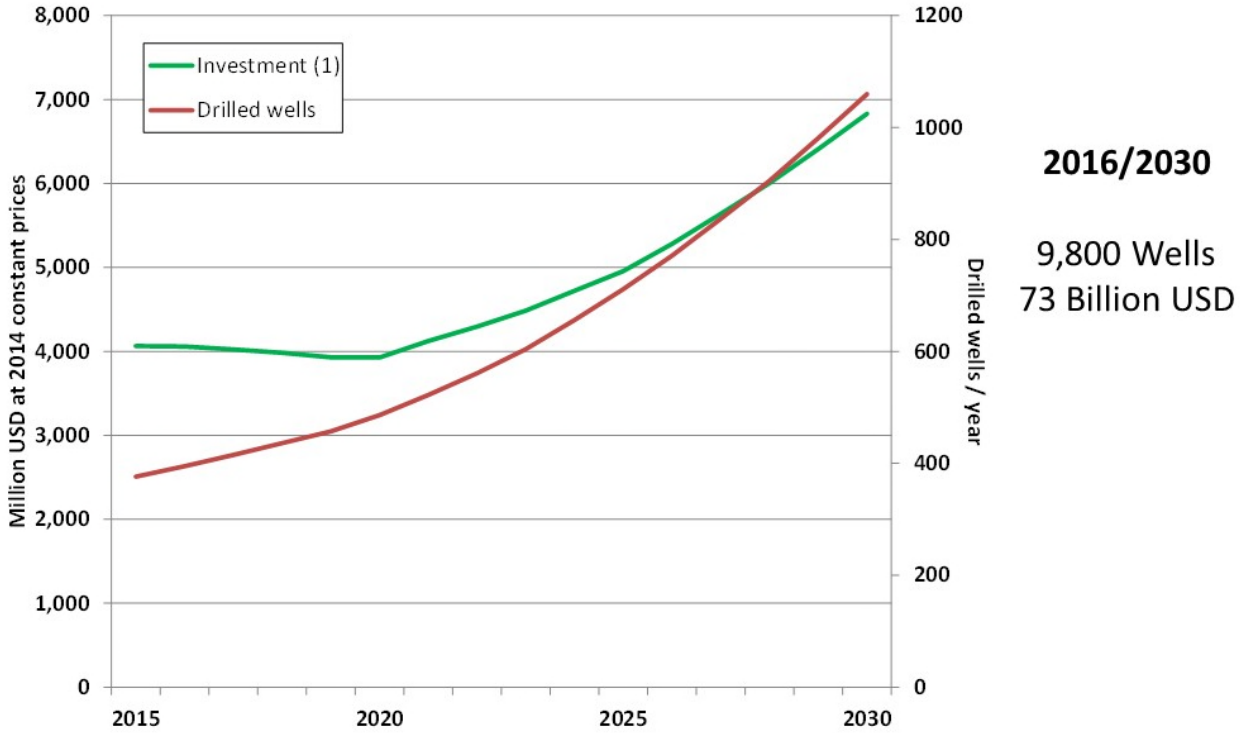
Figure 4.1.2 World Bank Brent Oil Price Forecast – 2016 / 2030



References:
2016/2017: World Bank Quarterly Report, January 2016.
2018/2025: World Bank Commodities Price Forecast, October 2015.
2026/2030: Values extrapolated in line with 2021/2025 cumulative annual growth rate.
Source: World Bank for 2016/2025, own extrapolation for 2026/2030.

- Unconventional oil and gas well drilling: Figure 4.1.3 shows the unconventional oil and gas drilling forecast performed as part of this simulation, resulting in a total of 9,800 wells for the 2016/2030 period. In the case of shale gas, the estimated drilling parameters and patterns replicate the conditions of Vaca Muerta, for vertical wells, and those of Eagle Ford, for horizontal wells. In the case of tight-sands gas, the model replicated a representative field in Neuquén (Centenario, operated by Pluspetrol). It was assumed that horizontal wells would grow significantly in the medium and long term, representing more than half of the total drilling activity in 2020 and with almost absolute predominance towards the end of the projected period.

Figure 4.1.3 Argentina: Tight-Sands Gas and Shale Well Drilling Assumptions – 2016 / 2030



Reference: (1) Includes exploration & development, completion, facilities and gathering system costs.
Source: Author estimates, based upon industry survey and projections.

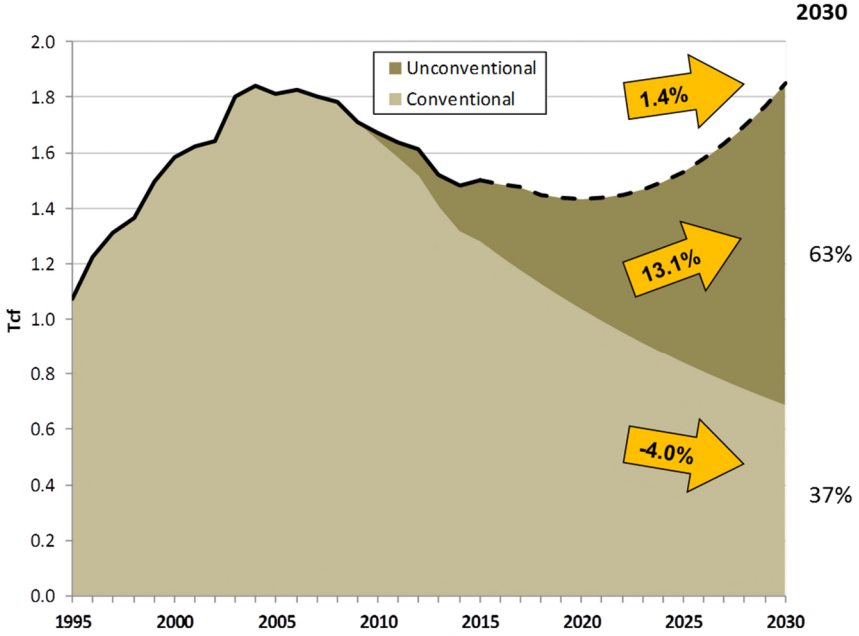
4.2 Demand and supply scenarios

A summary of the main results per scenario follows.

"Business as Usual" scenario

- Internal energy demand: 1.8% CAGR for 2015/2030 (ie, considering 2014 - the last year with complete public statistics - as the reference year).
- Natural gas demand: 1.4% CAGR for 2015/2030.
- Natural gas production (see Figure 4.2.1): 1.4% CAGR for 2015/2030, with unconventional (i.e., tight-sands and shale) gas increasing - on average - 13.1% per annum and attaining 63% of the domestic production forecast for 2030 - around 90 MMm^3/d (33 Bcma or 1.2 Tcf). This significant growth compensates the expected decline of gas production from "conventional" fields.

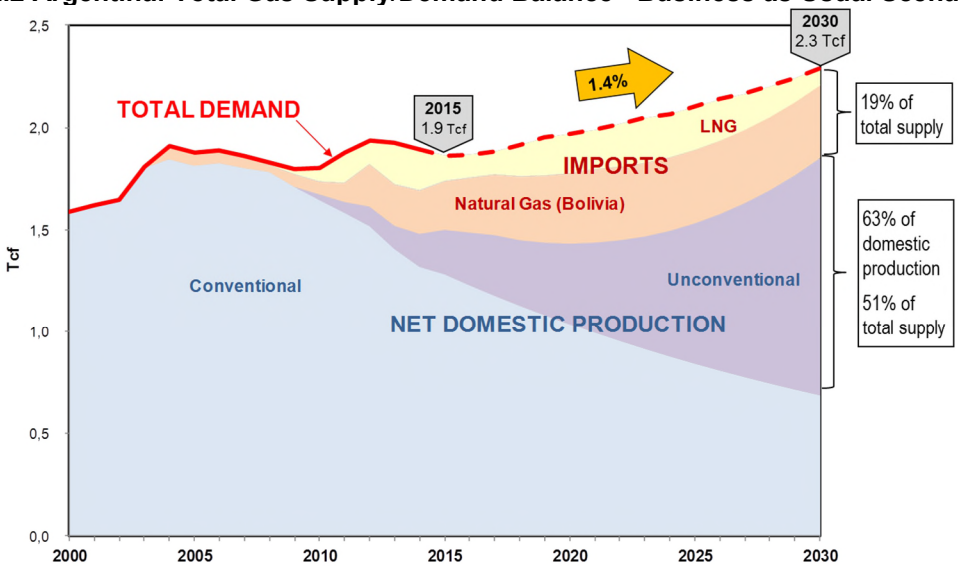
Figure 4.2.1 Argentina: Natural Gas Production Forecast – 2016 / 2030



Source: Author estimates.

- Natural gas supply/demand balance for 2016/2030 (see Figure 4.2.2): It is noteworthy that - despite the strong recovery expected in its domestic gas production - Argentina would continue to require imports throughout the whole period, with Bolivian gas and LNG still covering 19% of the total supply in 2030, within a context in which gas demand would grow at an 1.4% annual average rate from 2015 onwards.

Figure 4.2.2 Argentina: Total Gas Supply/Demand Balance - Business as Usual Scenario

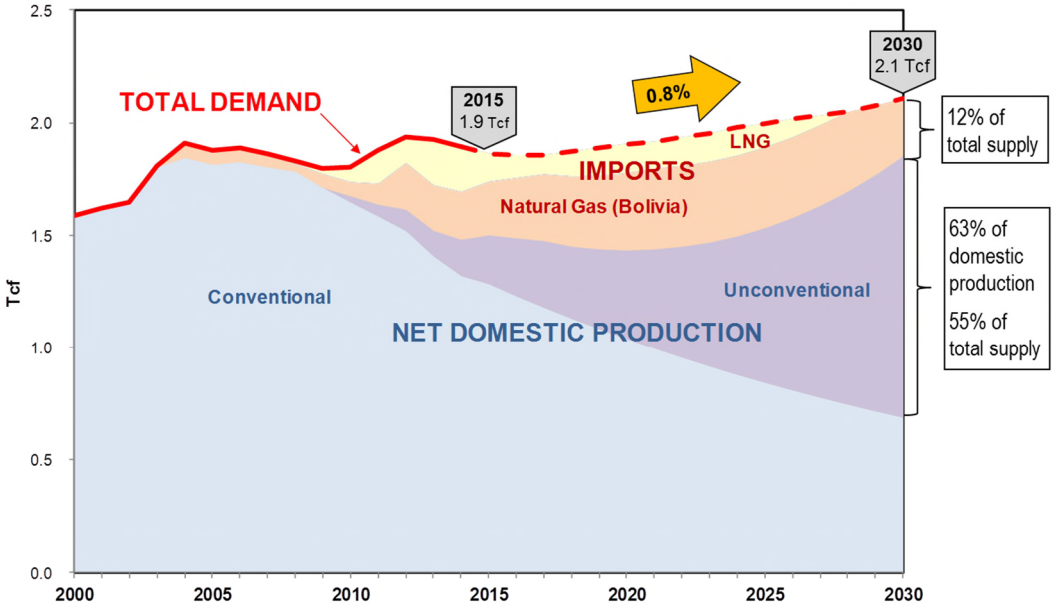


References:
Net Domestic Production: Excludes gas flaring.
LNG: Liquefied Natural Gas. Includes direct imports (Escobar and Bahía Blanca) and "indirect" imports (through Chile and Uruguay).
Source: Author estimates.

"Renewables and Energy Efficiency" scenario

- Internal energy demand: 1.2% CAGR for 2015/2030.
- Natural gas demand: 0.8% CAGR for 2015/2030.
- Natural gas production: Same as above.
- Natural gas supply/demand balance for 2016/2030 (see Figure 4.2.3): It is noteworthy that - despite the substantially lower growth in gas demand (due to intensive development of renewables and energy efficiency), and the strong recovery expected in its domestic production - Argentina would continue to require imports throughout the whole period, with Bolivian gas and LNG still covering 12% of the total supply in 2030. Consequently, if the country were to target the recovery of natural gas self-sufficiency in the medium term, the level of investment needed in exploration and production would be highly challenging[56].

Figure 4.2.3 Argentina: Total Gas Supply/Demand Balance - Renewables and Energy Efficiency Scenario



References:
Net Domestic Production: Excludes gas flaring.
LNG: Liquefied Natural Gas. Includes direct imports (Escobar and Bahía Blanca) and "indirect" imports (through Chile and Uruguay).
Source: Author estimates.

Composition of gas supply sourcing

Table 4.2.1 compares the expected evolution of domestic and imported natural gas supply by sources, for the Business as Usual and the Renewables and Energy Efficiency scenarios.

As mentioned, the domestic production forecast is similar for both scenarios. After 2025, unconventional gas would overtake conventional gas as the largest indigenous source of supply.

[56] Alternative scenarios developed by the authors show that - even with extremely ambitious E&P investment programmes, both for conventional and unconventional oil and gas - it seems unlikely that Argentina would be able to reach natural gas self-sufficiency prior to 2025.

Even if tight-sands gas would contribute with higher volumes throughout 2016/2030, shale gas production should present a more dynamic growth.

Under the Business as Usual scenario, in 2030 Bolivian gas/LNG imports would still amount to 34 MMm^3/d (12.5 Bcma or 0.44 Tcf), whereas in the Renewables and Energy Efficiency scenario such imports would account for 20 MMm^3/d (7.3 Bcma or 0.26 Tcf). The forecast assumes that Bolivian supply would continue to play a "base role", even after the expiry of the existing contracts - in 2027.

However, this will largely depend on how much gas Bolivia is able to produce post 2020, and how much it will deliver to its own domestic market and export to Brazil. As mentioned under Section 3.4, the current Bolivian reserves do not seem sufficient to meet Argentina's needs in either scenario; therefore, LNG imports will continue to play an important balancing role, and may eventually be higher than estimated in both scenarios.

The above-mentioned forecast implies that Argentina would increase unconventional gas production 5-fold between 2015 and 2030. If this does not happen, the contribution of imported LNG would increase, including imports of regasified LNG from Chile and possibly Uruguay.

Table 4.2.1 Argentina: Gas Supply Forecast, by Source - Business as Usual vs. Renewable and Energy Efficiency Scenarios

Gas Supply Sources		Business as Usual Scenario (Tcf)			Renewable and Energy Efficiency Scenario (Tcf)		
		2020	2025	2030	2020	2025	2030
Imports	LNG	0.2	0.2	0.1	0.1	0.1	0.0
	Natural Gas (Bolivia)	0.3	0.4	0.4	0.3	0.4	0.3
	Total Imports	**0.5**	**0.6**	**0.4**	**0.5**	**0.5**	**0.3**
Net Domestic Production	Shale Gas	0.1	0.3	0.5	0.1	0.3	0.5
	Tight Sands Gas	0.3	0.4	0.7	0.3	0.4	0.7
	Conventional Gas	1.0	0.8	0.7	1.0	0.8	0.7
	Total Production	**1.4**	**1.5**	**1.9**	**1.4**	**1.5**	**1.9**
Total Gas Supply		**2.0**	**2.1**	**2.3**	**1.9**	**2.0**	**2.1**

References:
Net Domestic Production: Excludes gas flaring.
LNG: Liquefied Natural Gas. Includes direct imports (Escobar and Bahía Blanca) and "indirect" imports (through Chile and Uruguay).
Source: Author estimates.

Investments required for 2016/2030

- The above described market simulation involves significant investment requirements in both scenarios.
- In the "Business as Usual" scenario, the energy sector would need to invest USD 250 billion (valued at 2014 constant prices) during 2016/2030 (i.e., an average of slightly over USD 16.5 billion/year). Oil and gas exploration and production activities would require USD 120 billion (or USD 8 billion/year), of which about USD 73 billion would be destined to the drilling of unconventional wells, as previously shown in Fig. 4.3. Natural gas transmission and distribution

would require USD 25 billion (or USD 1.7 billion/year) for the projected period, according to a study published by the Argentine Oil and Gas Institute (IAPG) in July 2015[57].

- In the "Renewables and Energy Efficiency" scenario, the energy sector would need to invest USD 220 billion during 2016/2030 (i.e., an average of slightly over USD 14.5 billion/year). The lower investment requirement – compared with the "Business as Usual" scenario - reflects the impact of the intensive development of renewables and energy efficiency on the power generation segment, whereas the oil / gas E&P and gas T&D activities' needs would remain unchanged.

In summary, unconventional gas production is expected to contribute almost two thirds of domestic supply in 2030, posing significant policy, investment and development challenges.

[57] (IAPG, 2015)

5. Unconventional gas development prospects

5.1 Investment outlook and producers' plans

Shale gas

The drop in oil prices has caused a slowdown of E&P activity in Vaca Muerta in 2016. International oil companies have slashed investment expenditure worldwide, with Wood Mackenzie predicting a global drop of USD 1 trillion in oil and gas CAPEX in the period 2016/2020. In this scenario Argentina could be hit by a cut of USD 1-5 billion.[58]

YPF 1Q2016 financial results also suffered when compared to the previous year, in part due to currency depreciation[59]. This will increase the company focus on reducing costs coupled to an announced 20-25% cut in CAPEX[60].

The government-incentivised domestic prices[61], of 54.9-67.5 USD/Bbl for oil and up to 7.5 USD/MMBtu for gas, may encourage domestic production but are much higher than the economic opportunity cost of importing crude from the Atlantic Basin and natural gas from Bolivia.

In addition, the Argentine government's authorisation for limited imports of light crude to recompose the margins of the country's oil refiners has caused some concern among shale oil producers, because this will reduce the attractiveness of oil production from Neuquén to the domestic refiners.

According to YPF, Vaca Muerta production in 1Q2016 dropped to 49,100 bbl/day due to a reduction in stimulation activity[62]. The Argentine press has published that YPF plans to reduce costs by 15-25%[63]. The overall number of rigs operating in Neuquén has fallen from 144 in June 2015 to 99 in June 2016. Drilling rigs in the Vaca Muerta shale area were cut to 11 from 17.[64]

As at August 15th 2016 Brent price was quoted at 49.90 USD/bbl. International analysts have previously estimated a breakeven price for Vaca Muerta oil at around 70[65]-85 USD/bbl[66]. The authors estimate a breakeven price range of 5.5-9.0 USD/MMBtu for Vaca Muerta shale gas and 4.0-5.5 USD/MMBtu for tight sands gas.

The maintenance of high government-incentivised oil and gas prices against a backdrop scenario of low crude prices does not seem sustainable in the medium/long term because it may contribute to the lower competitiveness of Argentine products. In the short term the government needs to balance the need for cheap and competitive supplies of gas to support the economy against high domestic oil/gas prices, in order to encourage oil companies to invest in new shale developments.

In its 2014 Investor Presentation YPF estimates that the full development of YPF/Chevron Loma Campana will require 1,500 additional wells to reach a production of 50,000 bbl/day of oil and 3.0 MMm^3/d of gas at a cost of USD 15 billion (YPF, 2014b). The CAPEX projection assumes an average well cost of USD 10 million.

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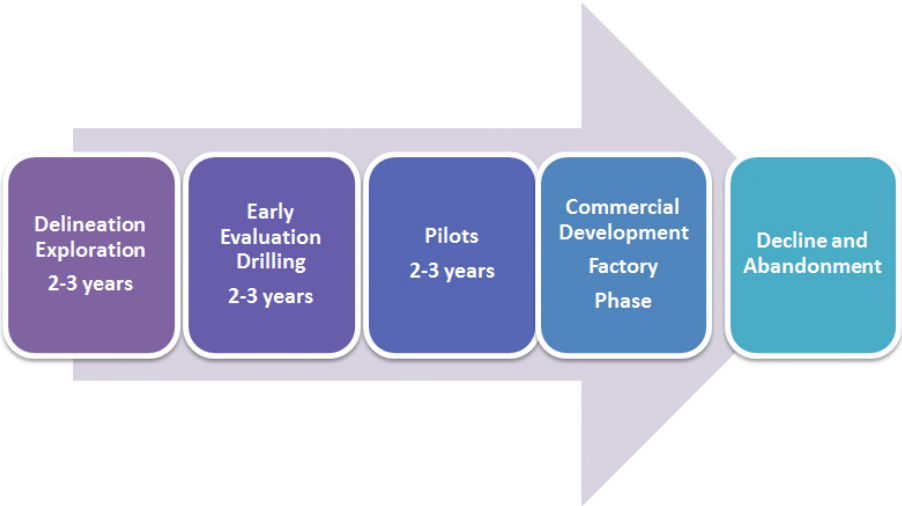
[58] http://www.woodmac.com/analysis/global-upstream-investment-slashed-by-US1-trillion
[59] (YPF, 2016)
[60] http://en.mercopress.com/2016/03/07/argentina-s-ypf-planning-to-cut-capital-expenditure-by-at-least-20-25
[61] Called locally ***"barril criollo"***
[62] (YPF, 2016)
[63] http://www.bloomberg.com/news/articles/2016-03-03/ypf-joins-oil-industry-budget-cuts-as-argentine-subsidy-shrinks
[64] http://www.bloomberg.com/news/articles/2016-03-03/ypf-joins-oil-industry-budget-cuts-as-argentine-subsidy-shrinks
[65] http://www.cronista.com/3dias/Vaca-Muerta-la-gran-promesa-que-busca-sortear-la-crisis-del-petroleo-20160520-0004.html
[66] (Morgan Stanley, 2014)

According to a report released in August 2016 by IHS Markit[67], Argentina will need 140 rigs and investments of 8.0 billion USD/year to be able to deliver 560,000 bbl/day of shale oil and condensates and 170 MMm3/d of natural gas by 2040[68]. In November 2015 Wood Mac estimated that the industry would spend a CAPEX worth USD 1.2 billion [69] in 2016 in Vaca Muerta; however local media sources inform that the budget has been cut to USD 600 million in 2016[70].

There are four critical phases for the development of shale, starting with understanding and delineating the resources, then building pilot projects and then implementing a factory model where large numbers of horizontal and vertical wells are drilled and completed on a repeated and tested mode. According to the experience in the USA, China and Argentina, it may take 6-9 years for a shale area to reach a full commercial development stage, the so-called "factory phase" (Figure 5.1.1). The only large scale Argentine shale project in early stage of field development is Loma Campana, whereas all the others are either in the pilot phase or in earlier evaluation stages[71].

Figure 5.1.1 Phases of a Shale Gas Project

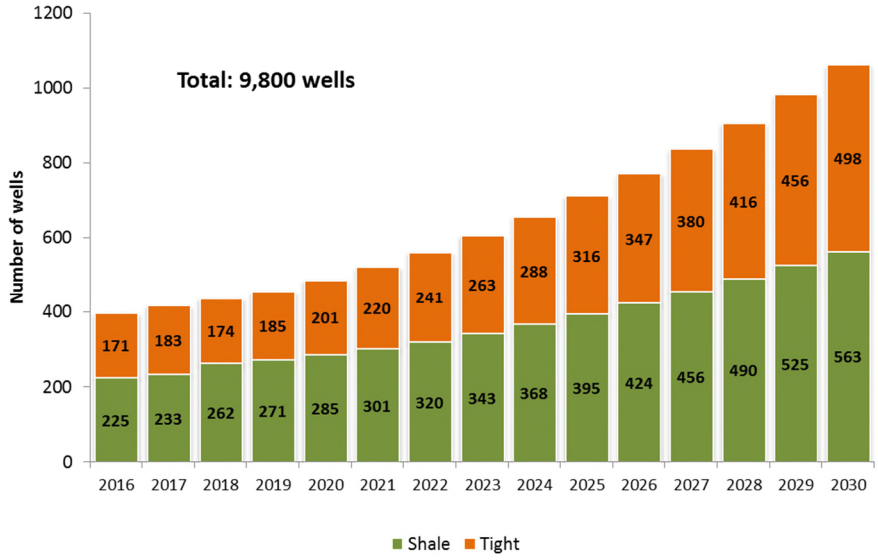


Source: Authors, based on information from public sources.

Taking into account the country specificities, coupled with a) the assumption that oil prices may not rise above 60 USD/bbl before 2020; and b) the breakeven levels required by unconventional producers in Argentina, within the forecasting exercise described in Section 4 the authors considered a gradual increment of shale and tight sands gas drilling in the next 3-4 years, with a total of 9,800 unconventional wells to be drilled in the period 2016/2030 (Figure 5.1.2).

[67] http://www.argentinashale.com/es/noticias/exploracion-y-desarrollo/vaca-muerta-requiere-una-inversion-anual-de-mas-de-us8000-millones
[68] The projection includes shale, tight and conventional oil and gas.
[69] http://www.ogj.com/articles/2015/11/woodmac-vaca-muerta-output-to-double-by-2018.html
[70] http://www.cronista.com/3dias/Vaca-Muerta-la-gran-promesa-que-busca-sortear-la-crisis-del-petroleo-20160520-0004.html
[71] El Orejano is also in an early field development.

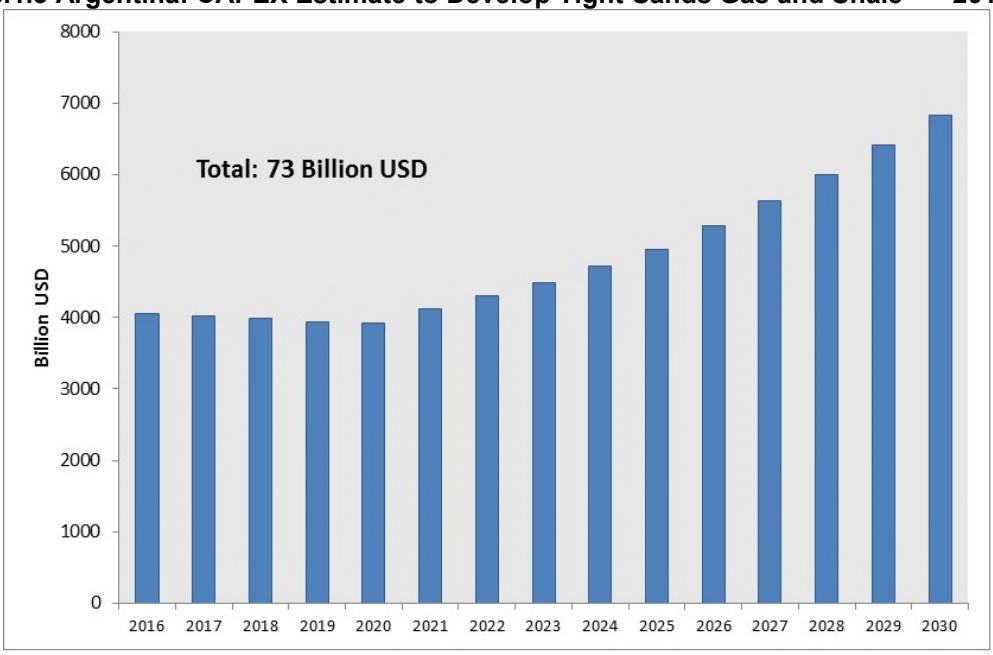
Figure 5.1.2 Argentina: Projected New Tight-Sands Gas and Shale Wells – 2016/2030



Source: Author estimates, based upon industry survey and projections.

This estimate assumes that 396 new wells will be completed in 2016, with an investment of USD 4.0 billion, which is substantially below initial industry forecasts of USD 6.0-8.0 billion/year but may well be over-optmistic in the face of the current industry slow down. The accumulated drilling and completion CAPEX is estimated at USD 73 billion (Figure 5.1.3). This would allow reaching production of around 90 MMm^3/d of unconventional gas by 2030 (see Section 4).

Figure 5.1.3 Argentina: CAPEX Estimate to Develop Tight-Sands Gas and Shale [(1)] - 2016/2030

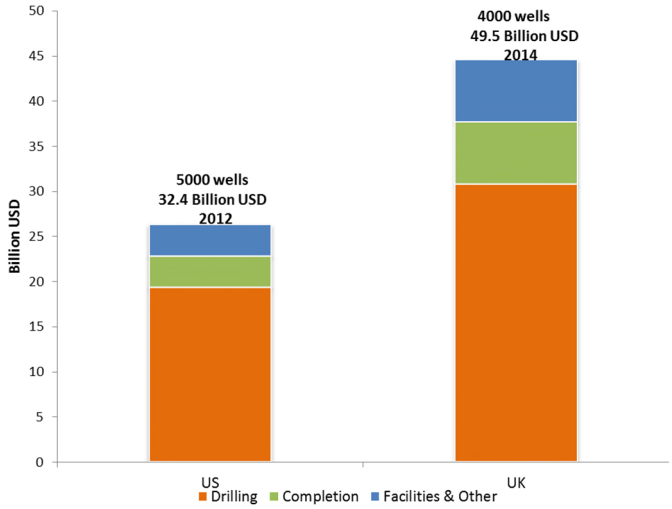


Reference: [(1)] Includes exploration & development, completion, facilities and gathering system costs.
Source: Author estimates, based upon industry projections.

These estimates assume continuous gains in efficiency and reduction of well costs.

Comparing Argentina projected CAPEX with actual costs incurred in the USA and forecasts for the United Kingdom (UK), which is still in the very early days of unconventional gas development, Argentina would fall roughly in the middle of the curve. For example, the investment for drilling and completing 5,000 wells in the USA in 2012 was in excess of USD 32 billion, on average USD 6.5 million/well, whereas EY[72] estimated that the UK would require nearly USD 50 billion for 4000 wells, on average USD 12.4 million/well (Figure 5.1.4).

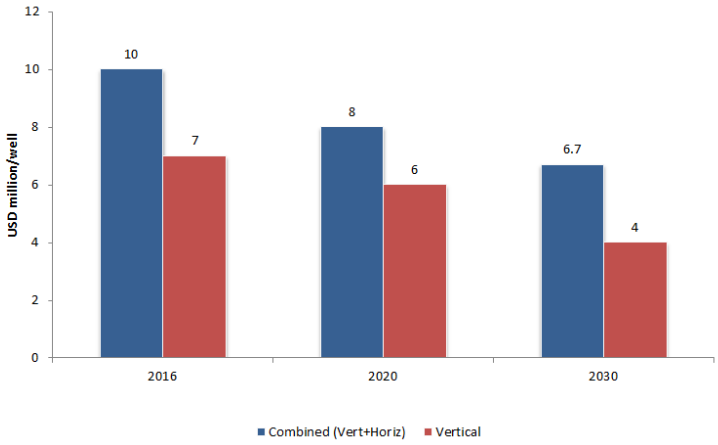
Figure 5.1.4 USA vs. UK: Upstream CAPEX - Shale Oil and Gas Development (1) (Billion USD)



Reference: (1) UK, 6 years for exploration, 40 lateral wells.
Source: Taylor, 2013 and EY, 2014.

Due to Argentina's local specifics, including tax, labour, logistics and equipment availability, the authors believe that it is unlikely that Argentina will reach the same benchmark as the USA, with cost efficiency taking place gradually until the cost for a combined horizontal/vertical well drops to USD 6.7 million and a vertical well drops to USD 4.0 million by 2030 (Figure 5.1.5).

Figure 5.1.5 Argentina: Average CAPEX Estimate to Develop Tight-Sands Gas and Shale, by Type of Well (1) – 2016/2030



Reference: (1) Includes exploration & development, completion, facilities and gathering system costs.
Source: Author estimates for future costs.

[72] (EY, 2014)

Tight-sands gas outlook

The oil companies seem to be taking a cautious approach to developing tight sands gas, which requires lower CAPEX than shale gas, as they can produce using predominantly vertical wells with hydraulic fracturing, at a cost of around USD 7 million/well.

The producers holding concessions in Neuquén were planning to invest around USD 500 million in tight sand gas projects from 2015 onwards[73].

- YPF is developing the tight sands gas formations of Lajas and Mulichinco, where it currently produces 6.7 MMm^3/d, with plans to drill 30 tight-gas wells in 2016.
- Pan American Energy is currently producing 2 MMm^3/d of tight-sands gas on its Lindero Atravesado concession, in addition to conventional gas.
- Total has been producing tight sands gas on its concession in Aguada Pinchana for more than five years[74].
- Pluspetrol plans to drill 45 tight sands gas wells in Neuquén with a total cost of USD 315 million.
- Petrobras is drilling tight sands gas wells on its Rio Neuquén concession.

The oil companies have different perspectives with regard to which production volumes they deem as economically attractive. Whereas Pluspetrol estimates that an accumulated volume of 3.5 Bcf seems viable, Pan American Energy considers that the wells are viable at an accumulated volume of 7.7 Bcf spread over 30 years. Due to the exponential production profile, it might take 7-10 years to recover half of the 30-year cumulated production, whilst a conventional project requires half of this time [72].

Another point mentioned by industry players at conferences and press materials is the longer time taken to complete and connect wells in Argentina, which may be caused by the lack of local knowledge about the operation of automated drilling units, among other factors.

5.2 Key challenges

Oil and gas ventures in general, and the development of unconventional resources in particular, usually face key “below and above surface” challenges. The former represent a clear “go/no go” situation, whereas the latter pose conditioning factors that can either encourage or discourage such development, even in the presence of favourable geological starting points and prospects.

As described under Section 3.3, Argentina’s “below surface” starting point and prospects seem clearly favourable, given the existence of significant technically recoverable unconventional oil and gas resources, particularly in the Neuquén Basin, where there are several areas of comparable quality to those that were discovered in the USA. Geography and demography are also favourable, as these resources are mostly found in relatively plain surfaces and sparsely populated areas.

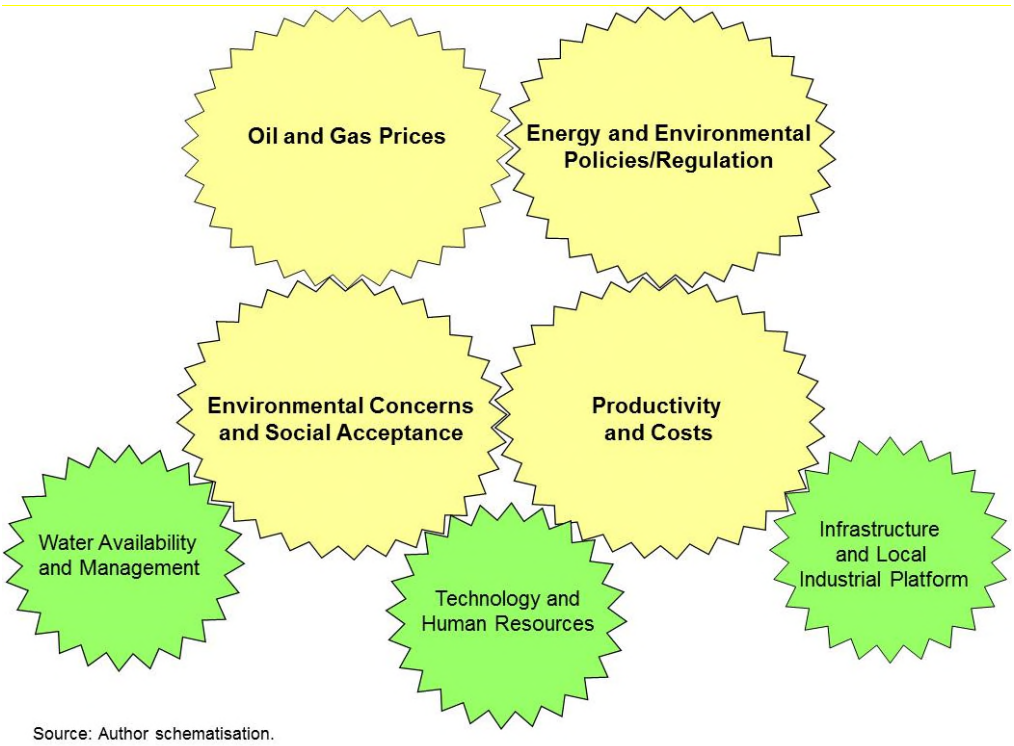
The analysis that follows will therefore focus on the “above surface” dimension, with a view to identify the main barriers or obstacles to overcome, in order to transform such resources into reserves and these into sustainable and marketable production.

Figure 5.2.1 identifies seven key “above surface” challenges for unconventional gas development. The four challenges highlighted in yellow are considered the most critical medium and long term “doability and sustainability conditioning factors” for Argentina. The three challenges highlighted in green are slightly less critical, but also highly relevant.

[73] http://www.inversorenergetico.com.ar/tight-gas-la-llave-de-entrada-los-convencionales-eligen-las-petroleras/
[74] http://www.platts.com/latest-news/natural-gas/buenosaires/total-targets-argentina-shale-offshore-to-boost-26233952

Each of these challenges are covered below, following a research process that included interviews with - and/or questionnaires completed by – representatives of governmental agencies, oil and gas companies, professional associations and NGOs, and consultation of individual experts and bibliography.

Figure 5.2.1 Argentina: Key Challenges for Unconventional Gas Development



Source: Author schematisation.

Key challenge No. 1: Oil and gas prices

There seems to be a widespread consensus that - at the international oil and gas prices prevailing in mid-2016, and despite the fact that domestic prices are temporarily decoupled and set at higher levels - in the short term the expansion of unconventional gas production will mostly come from tight-sands gas, whereas new investments in shale will be kept at a minimum, in a context in which CAPEX levels of most international companies have been sharply reduced and financing costs remain high for Argentina. However, as shown under Section 4, shale gas has a key role to play in the longer term.

Most key players believe that a recovery of international oil prices to 65-70 USD/Bbl would constitute a positive signal and would help reactivate E&P investments, subject to productivity improvements and operational cost reductions (dealt with under Key challenge No. 3).

With regard to unconventional gas, there is some degree of price uncertainty in the short term. On one hand, the USD 7.5/MMBTU incentive price established within the “Plan Gas” programme expires in December 2017, although - as mentioned under Section 3.3 - the government is currently assessing the way forward On the other hand, subject to the result of the public hearing ordered by the Supreme Court on August 18 (and called for on September 16), the Macri administration has not yet been able to implement a gas pricing policy that aimed to relaunch investments along the different segments of the value chain.

It is worth highlighting that one of the main operating companies has suggested that - given the different types and costs of fields involved - it becomes increasingly important to "manage production portfolios", with gas price and income mixes that will inevitably vary over time.

Key challenge No. 2: Energy and environmental policies and regulation

Unconventional oil and gas development became a top priority energy policy issue during President Cristina Kirchner's second term (2011/2015), and - from mid-2012 onwards - the State-controlled oil company YPF (rather than the former Energy Secretariat) acted as the main "driver" of both regulatory and investment initiatives in this matter. The highlights of this process were (i) the issuing of new legislation to promote unconventional oil and gas investments during 2012/2014 (notably, Decree 929/12 and Law 27007, in 2014), as described under Section 3.2; (ii) the launching of special pricing incentives under the so-called "Plan Gas" programme, in January 2013, as explained in Section 3.3; and (iii) the direct involvement of leading international and domestic oil and gas companies in the Vaca Muerta play, as mentioned under Section 3.5.

Even if this governmental initiative raised great interest - and resulted in significant investments in - unconventional oil and gas development in Argentina, its main weakness derived from the fact that it was not part of an overall energy policy or strategy (which the previous government lacked), but was almost an "end" in itself, and the main justification for the high priority and exposure assigned to this matter was the need to recover national oil and gas self-sufficiency (which was lost during Mrs. Kirchner's presidency).

The administration led by President Macri, that took office in December 2015, has not yet formulated a comprehensive energy policy framework either - and has been mostly absorbed by the urgent need to redress short-term energy shortages and significant negative fiscal impacts resulting from 12 years of distorted and heavily subsidised prices - but has announced its intention to issue a National Energy Plan towards the end of 2016, and has followed some broad policy guidelines made public by the Ministry of Energy and Mines in public statements and presentations[75].

These guidelines include; (i) the gradual normalisation of regulatory institutions and energy markets; (ii) the improvement of energy access and utilisation, in the latter case through ambitious energy efficiency initiatives; (iii) the contribution to economic development through adequate energy supply; and (iv) the diversification of the National Energy Balance, with increasing participation of renewable energy sources, especially in power generation.

Within these guidelines, most of the government's energy initiatives have targeted (i) active promotion of energy efficiency, on the demand side; (ii) gradual replacement of imported gas by domestic production, fast-track incorporation of new power capacity and generation (for an electricity sector that was formally declared "in emergency") and significant development of renewables, on the supply side; and (iii) the immediate reformulation of energy pricing policies and adjustment of tariff levels, with a view to gradually converge towards the coverage of economic costs and significantly reduce the fiscal impact of pre-existing subsidies, while aiming to align or at least "relate" - currently "decoupled" - international and domestic price signals in the medium term.

Given that the "energy supply diversification" objective seems to have widespread consensus - among policy-makers, business leaders, academia and NGOs -, it is reasonable to expect a future reduction of the current (51%) contribution of natural gas. Notwithstanding the above, gas is expected to continue to be the first source of energy supply, for which purpose - in view of the strong production decline of conventional reservoirs shown under Section 4 - unconventional gas development will still play a significant role, provided that it is cost-competitive (against alternative sources of energy) in the medium and long term.

[75] (Redondo, 2016)

In summary, whenever the Argentine government formulates its National Energy Plan, it is likely that unconventional (oil and) gas development will maintain high priority, although as "one of the key contributors" to solve the present domestic energy demand/supply imbalance, and not as "the solution", as was publicised by the previous administration. NGOs go one step further and consider that - in order to ensure this "one amongst others" approach - it would also be advisable to modify Law 27007 that introduced special regulatory principles for unconventional oil and gas concessions - through amendment of Law 17039 - in 2014.

It is worth mentioning that the energy - and hydrocarbons - policy is formulated by the national government, but concession licensing and operational control are the responsibility of provincial administrations. This poses an additional "coordination challenge", that will be addressed further on.

As mentioned under Section 3.2, environmental policies and regulations are issued both by the national government - through the Ministry of Environment and Sustainable Development (MAyDS) – and the provincial administrations.

In the case of the oil and gas industry, the Neuquén government closely supervises the concessionaires' compliance with environmental best practices. (See also Key challenge No. 5, regarding water use.) The relationship between the provincial authorities and the operators is fluent and based on open dialogue, although some NGOs argue that there is significant disparity of technical means between the controller (whom they deem weak) and the controlled (whom they see in an advantageous position). NGOs also consider that the oversight of unconventional oil and gas activities would require special environmental regulations, eventually as an amendment to Law 27007.

As anticipated, there is a general perception that there is room for improvement in the coordination of the issuance of regulations and actions taken by energy and environmental authorities, especially between the national and provincial levels. Some of the governmental sources consulted mentioned that there is ongoing dialogue between national and provincial authorities with a view to (i) minimising potentially negative environmental and social impacts of oil and gas operations on regional economies; (ii) harmonising environmental regulations; (iii) planning infrastructure expansion; and (iv) increasing local supply of goods and services - for growing populations - without triggering local inflation.

Finally, it should be highlighted that the macroeconomic context will - as always - strongly condition the ability of the energy and environmental authorities to design and coordinate more predictable policies.

Key challenge No. 3: Environmental concerns and social acceptance

Environmental concerns related to the use of hydraulic fracturing methods for unconventional oil and gas development have been widely covered since the start of the "shale revolution" in the USA, and - throughout the years - have led to a more rational and fact-based discussion. Among others, such concerns have comprised the following topics[76]: (i) land use footprint; (ii) possible pollution of drinking water; (iii) large scale water usage; (iv) potential effects of chemical fluids used for fracturing purposes; (v) wastewater disposal; (vi) air emissions; and (vii) the level of noise (sound pollution) derived from the operations.

The associated key challenge refers to social acceptance of unconventional oil and gas development, which - in the case of Argentina in general, and the Province of Neuquén in particular - has been high from the outset, with minimum conflict in comparison to the US experience or to mining activities (which faced social pushback in other regions of the country, notably in the Province of Mendoza).

[76] For further information it is recommended to consult (IGU, 2012), (Academia Nacional de Ingenieria/Instituto de Energia, 2013); and (IAPG, 2014)

Among others, the reasons for this acceptance are related to: (i) the low population density of the areas affected by the operations; (ii) the extensive track record of the oil and gas industry in the Neuquén Basin, an activity that is closely known by - and employs a significant part of - the local population; and (iii) the fact that drilling is done at a depth of approximately 3,000 metres, using cement casing isolating techniques that prevent any contact with - or leaks into - drinkable water aquifers, which are found at a depth of up to 250 metres (in the few locations in which there actually is drinkable water close to operational sites). Water use and management are a relevant source of concern for the Neuquén government and population, and are therefore treated separately (under Key challenge No. 5).

Despite this high level of acceptance of unconventional oil and gas activities, there is a wider range of perceptions with regard to the actual community engagement of the operating companies, and its impact on the so-called "social license (to operate)". The corporate viewpoint stresses the significant investments devoted to Social Responsibility (SR) programmes, environmental preservation initiatives, and ongoing efforts to improve transparency (through public information), adopt best practices and follow up on the local population's perceptions and concerns. NGOs argue that SR programmes are largely marketing tools and have low impact, and that the corporate environmental protection actions are too focused on mitigation and remediation, whereas they see the need to embed environmental and social plans from the early project stages (ie, during the basic engineering design).

One of the NGOs suggested that development plans should be designed on a regional or basin scale, rather than by concession areas, and identified the following actions to ensure a lasting "social license": (i) "compensation" for water volumes used during the hydraulic fracturing stages, by investing in the preservation of drinkable water (even in areas not directly affected by the operations); (ii) asset planning development oriented to minimise interference with other local productive activities, providing timely information on project start-up or relevant movements to the population; (iii) public disclosure of the number and location of wells drilled, and the volumes of water and types of chemical fluids used for drilling purposes (as done - through dedicated websites - by the US operators); (iv) "compensation" for unavoidable environmental impacts (eventually in other locations), especially regarding land use and effects on biodiversity; and (v) close coordination with regional and local authorities, to ensure that the unconventional oil and gas activities will bring about infrastructure development benefits for the neighbouring towns.

Key challenge No. 4: Productivity and costs

Even if the national and international companies involved in unconventional oil and gas development are making significant progress, the industry is still in the early stages of the "learning curve", and there is great room for improvement in productivity. In addition, in most areas of activity, Argentine capital expenditure (CAPEX) and operational (OPEX) costs are - in most cases - at least twice as high as those in the USA.

Productivity can be improved by: (i) improving economies of scale; (ii) increasing operator competition, ideally through the coexistence of larger corporations with medium-sized or independent companies; (iii) increasing service company competition, with a view to optimise the technologies applied (especially, in well engineering techniques); (iv) increasing availability - and cost reduction - of drilling rigs; (v) ongoing training of the professional staff and workforce (for instance, regarding the specific conditions of 24-hour fracturing activities); and (vi) more flexible conditions of trade union agreements.

In the case of Vaca Muerta, in recent years the Neuquén government launched certain initiatives to encourage operators to integrate in an "unconventional oil and gas cluster", following models similar to those of the electronic and IT industries in Silicon Valley (California, USA), the biotechnology sector in St. Louis (Missouri, USA) or the agricultural "seed complex" in the Provinces of Buenos Aires and Santa Fe (Argentina).

As mentioned, Argentine costs are significantly higher than in the USA. (Examples for drilling and completion - representing approx. 80% of CAPEX - were provided under Section 3.5.) The main areas in which cost reduction will be required are: (i) technical services, especially in drilling and completion (where one of the operators suggested focussing on technology improvements, non-productive time cost impacts and continuous working patterns); (ii) key supplies, such as proppant[77], mud and water; (iii) labour; (iv) truck transport and logistical support services; and (v) equipment import duties and procedures (which are already in the process of being reduced and simplified).

In the case of labour, the rigidity of the existing trade union agreements impacts both on the number and cost of staff. In the Neuquén Basin area, the relationship between the companies and the union has given rise to fewer areas of conflict than in the Golfo de San Jorge or Austral basins, but "competition between unions" strongly conditions the agenda. One of the leading operators suggested that it could be helpful to initially focus on the rebalancing of fixed and variable costs, with a view to introducing greater flexibility in some labour stipulations (such as shifts, catering or Social Security). In any case, the road map towards potentially significant cost reductions is expected to be long and challenging.

Finally, financing costs also represent a critical conditioning factor. Argentina is still a high-risk investment country, for which reasonable access to international finance is expensive; a reduction of such costs will depend on the improvement of the country's macroeconomic situation. Domestic financing is not a realistic option, as the country's (limited) capital market is not yet prepared to provide credit for the development of unconventional oil and gas projects.

Key challenge No. 5: Water availability and management

Water availability and management can constitute significant conditioning factors for unconventional oil and gas development. In the case of Argentina - and Neuquén - the former does not seem to pose a major challenge, whereas the latter has been strictly regulated by the provincial authorities, in order to address social concerns.

In general terms, water is abundant in the Neuquén Basin, which is traversed by three main rivers: Colorado (to the North), Neuquén (in the Center and East) and Limay (to the South). Availability, in general terms, is not a major concern: it is estimated that only 5% of the total resource is required for human, agricultural (irrigation) or industrial uses, and less than 1% for full-scale development of unconventional oil and gas operations[78], whereas the remaining 94% continues its course and ends in the Atlantic Ocean.

However, as highlighted by one of the local operators, only the Neuquén River is relevant as a direct source of supply - due to its closeness to the highest potential reserves area of the Vaca Muerta formation -, whereas in many cases water has to be transported to the fields by trucks. Consequently, from an operational standpoint, water availability can be a competitive advantage or not, depending on the location of the fields.

As mentioned, water use and management is strictly regulated by the Neuquén government, through Decree 1438/12, that stipulates that hydraulic fracturing activities may only use water from above surface sources (such as rivers or lakes), and bans the extraction of water from underground aquifers[79], reserved for human or irrigation uses. Wastewater recycling must also be managed according to specific procedures, in line with international best practices.

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[77] In the case of proppant, an initial "sand factory" project has been discarded, and operators are now focusing their efforts on the optimisation of the "supply pipeline", with the expectation of significantly reducing current cost levels.

[78] According to industry sources, hydraulic fracturing requires between10 and 30,000 m^3 of water per well (during its full productive cycle), depending on the geological formation and the drilling methods used. Vertical drilling requires up to a maximum of 6,500 m^3/well and horizontal drilling up to 12,000 m^3. Finally, each fracture stage uses approx. 1,000 m^3 in the case of shale and 400 m^3 for tight-sands gas.

[79] The Province of Chubut, with some - smaller scale - unconventional oil and gas activity, has issued similar regulations.

Water management challenges are therefore partly related to cost elements, notably usage charges - as well as relatively lengthy and complex permitting processes - and large-scale truck transport. With regard to the latter, a few years ago the Neuquén government launched the "Red Azul" (Blue Network) project, aiming at the construction of an aqueduct system that would simultaneously source unconventional oil and gas and agricultural activities, but no investment decision followed. In some US basins, aqueducts have proved very effective to help reduce both the level of costs and noise (sound pollution) of large-scale truck transport.

Key challenge No. 6: Technology and human resources

The different stakeholders contacted seem to share the viewpoint that - even if Argentina's and Neuquén's oil and gas industry and services have a wealth of experience, based on a skilled workforce - a large scale development of unconventional oil and gas would need to overcome significant technological and human resource challenges.

With regard to technology, local companies seem to have assimilated international best practices in a swift manner, and should take advantage of the relevance of the Vaca Muerta play to (i) develop and register new technologies as they progress along the "learning curve" and (ii) be prepared to share their own experience and best practices abroad, especially in Latin America. In this respect, the Energy Institute of the Argentine Engineering Academy (IE/ANI) sees some potential for the export of local unconventional oil and gas know-how and services in the longer term[80].

Concerning human resources, it seems key to (i) continue and extend collaborative experiences between operators; (ii) develop research programmes integrating operators and academia (as successfully done in Brazil, for offshore E&P activities); and (iii) identify, plan and cover the significant demand for young professionals and skilled workers required by the oil and gas companies, with the active participation of national, provincial and municipal authorities, universities and research institutes, labour unions, local population and NGOs.

Key challenge No. 7: Infrastructure and local industrial platform

Given that the most significant unconventional gas resources and reserves - and all relevant development ventures - are located in the Neuquén basin, the analysis of the "infrastructure challenge" will be circumscribed to that area.

According to the Argentine Oil and Gas Institute (IAPG)[81], in the Neuquén Basin pipeline network there is currently spare injection capacity available for approximately 30 MMm^3/d (20 for the domestic market and 10 on pipes to Chile). The existing infrastructure should be sufficient to evacuate unconventional gas from Neuquén until at least 2020. After that it could be necessary to add capacity, unless conventional resources were to decline faster than expected.

At a regional level, the gathering network is expected to face bottlenecks in the short term, and would require new pipelines - or, as stated by one of the operators, a "new supply geography" - from the producing fields to be connected.

In addition to gas pipeline expansions, the development of Vaca Muerta poses significant infrastructure and logistical requirements.

Figure 5.2.2 shows an estimate of such requirements by 2030, according to a recent study of the Energy Institute of the Argentine Engineering Academy (IE/ANI)[82]. It should be noted that the order of magnitude of these requirements is of great significance for Argentina and Neuquén.

[80] (Academia Nacional de Ingenieria, 2011)
[81] (IAPG, 2015)
[82] (Academia Nacional de Ingenieria/Instituto de Energia/Instituto de Energia, 2014)

Figure 5.2.2 Vaca Muerta (Neuquén/Argentina): Infrastructure and Logistics Requirements for Unconventional Oil and Gas Development – 2030 Estimate

MAIN SUPPLIES AND SERVICES	INFRASTRUCTURE (Excl. Gas Pipelines) (1)	LOGISTICAL SUPPORT SERVICES
▪Water: 11.2 million m^3	▪Aqueducts:	▪Oil camps:
▪Proppant: 7.5 million tonnes (150 x 10^6 bags)	✓Highly recommended	✓Large-scale catering
▪Pipes (for drilling tasks): 12,300 km and 633,000 tonnes	✓Neuquén "Red Azul" (Blue Network) project, paralyzed	✓Maintenance
▪Cement concrete: 1.5 million tonnes	▪Roads:	✓Storage
▪Fracking power: 580,000 HP	✓Need for new construction and rehabilitation of existing roads	▪Añelo (Neuquén town, closest to field operations):
▪Transport (number of trucks):	▪Railroads:	✓Large-scale housing / hotel capacity expansion
✓100% by vehicles: 4,900	✓New railroad line Neuquén-Añelo (100 km)	✓Public services
✓Combined with aqueducts: 2,700	✓Rehabilitation of load transport line B. Blanca-Neuquén (570 km)	✓Sundry general services
✓With aqueducts plus railroad: 800		

Reference: (1) Excludes trunk gas pipeline system expansion requirements, analysed separately.
Source: Adapted from Academia Nacional de Ingeniería (ANI) / Instituto de Energía - "Requerimientos para el desarrollo del reservorio de Vaca Muerta (Neuquén/Argentina)", December 2014.

This significant infrastructure expansion effort would require (i) the development of new value chains, as well as the creation of an adequate local industrial and suppliers' platform; (ii) a collaborative effort on behalf of all key players, to improve economies of scale throughout the "learning by doing" process; and (iii) identifying and planning the logistical needs in advance, to ensure their coverage from either national or imported sources of supply.

6. Key success factors to develop unconventional gas

6.1 Key enablers and lessons derived from the USA experience

The shale "revolution" was fundamental in transforming the USA into a nearly self-sufficient oil and gas economy, with considerable economic gains for the country and consumers.

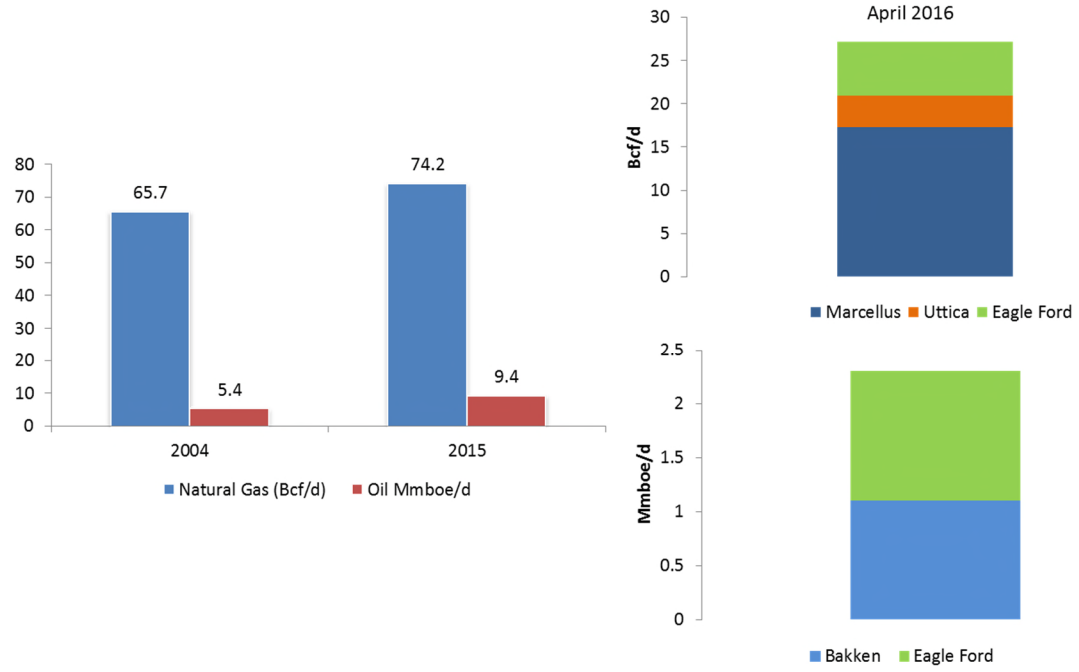
Before the start of the shale revolution, the USA produced 65.7 Bcf/d of natural gas and 5.4 million Bbl/day of oil in 2004. It built infrastructure to import 11 Bcf/d of natural gas through LNG terminals built in the East and Gulf coasts, which soon became idle.

By 2015 the USA produced 74.2 Bcf/d of natural gas and 9.4 MM Bbl/day of oil and condensates and, in addition to increasing its natural gas pipeline exports to Canada and Mexico, it started to export LNG from the Gulf Coast in 2016.

Shale was pivotal to the increase in oil and gas production in the USA. The production of natural gas was relatively flat in the period 1995/2005. Then the shale gas revolution started. The production of shale gas rose from 21 Bcm in 2005 to 376.5 Bcm in 2014, an 18-fold increase [83](Figure 6.1.1). The most substantial growth occurred in the Marcellus play (Pennsylvania), where production rose from 0.2 Bcm in 2007 to 177 Bcma (data as of June 2016).

Eagle Ford and Bakken contributed half of the increase in oil production, whereas Marcellus, Eagle Ford and Utica accounted for 36.7% of the entire production of natural gas in the USA.

Figure 6.1.1 USA: Shale Contribution to Natural Gas and Oil Production – 2004/2015



Source: EIA Drilling Productivity Report, July 2016

[83] https://www.eia.gov/dnav/ng/hist/res_epg0_r5302_nus_bcfa.htm

According to (Oudenot, 2013) there are 12 key exploration and development parameters to determine the quality and the economics of a shale formation (Table 6.1.1):

Table 6.1.1 Key Exploration and Development Parameters - Shale Quality and Economics

Exploration phase	Development phase
Formation depth	Well costs
Total organic content	Initial production and estimated ultimate recovery
Net thickness of the shale layer	Liquid and natural-gas-liquid content
Thermal maturity	Environmental requirements
Formation overpressure	Local commodity prices and taxation regime
Silica and clay contents	Access to infrastructure

Source: (Oudenot, 2013)

Vaca Muerta is usually compared as an analog to the Eagle Ford shale in Texas, and compares more favourably in terms of TOC (Total Organic Content) and formation thickness (Table 6.1.2 and Figure 6.1.2)[84]. Vaca Muerta is also oil and gas prone.

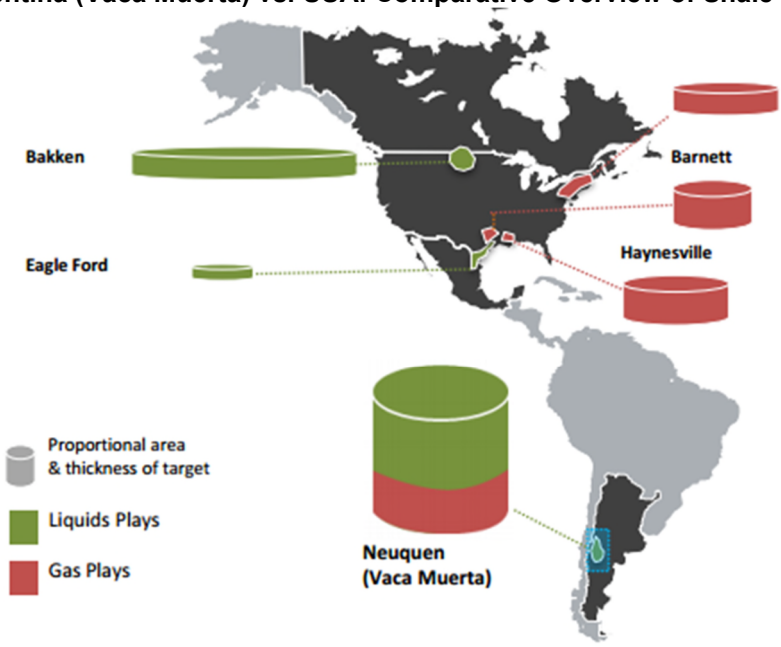
Table 6.1.2 Comparison of Vaca Muerta with US Shale Formations

	Vaca Muerta	Barnett	Haynesville	Marcellus	Eagle Ford
TOC (%)	3-10	4-5	0.5-4	2-12	3-5
Thickness (m)	30-450	60-90	60-90	10-60	30-100
Reservoir Pressure (psi)	4500-9500	3000-4000	7000-12000	2000-5500	4500-8500

Source: (YPF, 2014a)

[84] For further information, see http://iapghouston.org/media/k2/attachments/UnconventionalOffshore_-_final.pdf

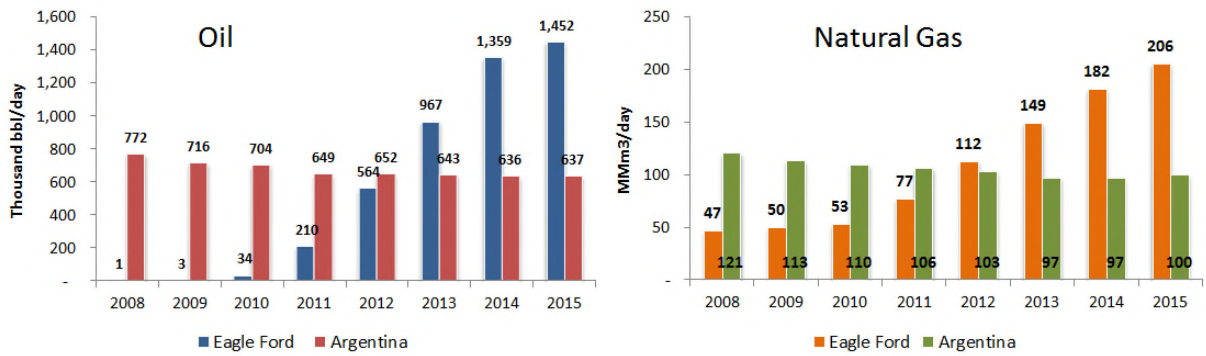
Figure 6.1.2 Argentina (Vaca Muerta) vs. USA: Comparative Overview of Shale Formations



Source: IAPG Houston, 2015.

The development of Eagle Ford started in 2008, with very little production taking place up to then. Within three years it was producing 210,000 Bbl/day of oil and 77 MMm^3/d of gas. By 2015, Eagle Ford production was more than the double the whole Argentine production of conventional and unconventional oil and gas (Figure 6.1.3).

Figure 6.1.3 Argentina vs. USA: Vaca Muerta vs. Eagle Ford Play Oil (1) and Gas Production – 2008/2015

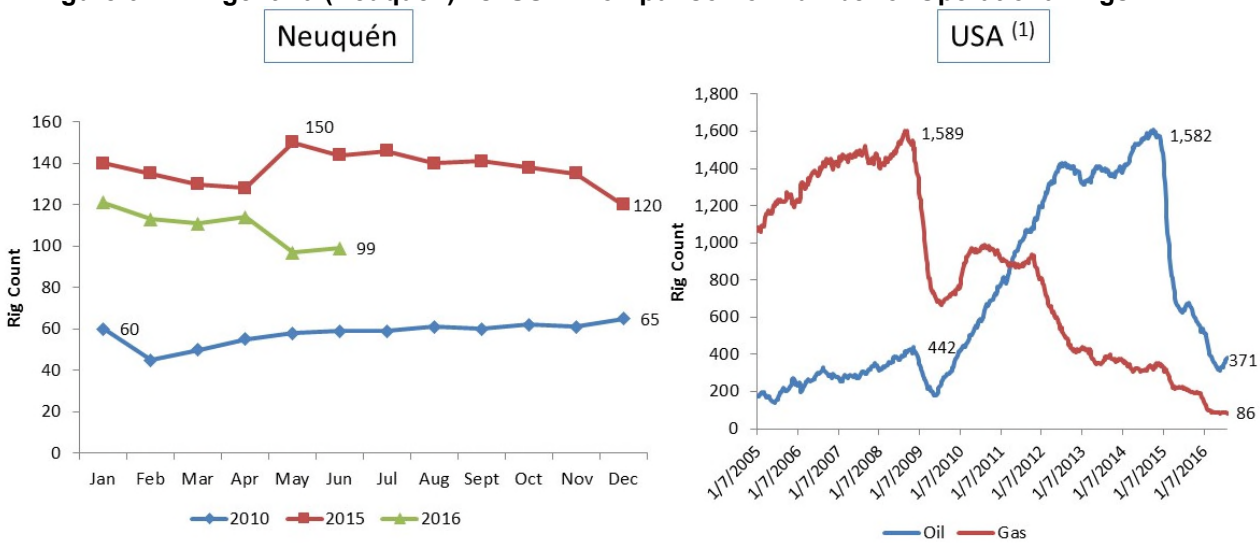


Reference: (1) Oil Production includes shale oil and NGLs.
Source: BP Statistical Review of World Energy 2016 and Texas Railroad Commission, 2016.

The availability and deployment of drilling rigs is one of the key factors for the increase in production of unconventional gas. In its heyday, the US count was 1,589 natural gas rigs in 2009; when gas prices dropped, but oil prices still continued to hold, this shifted to 1,582 oil rigs in late 2014.

In contrast, there were only 99 drilling rigs operating in Neuquén in June 2016, from a maximum of 150 in May 2015. In the early production years the rig count in Eagle Ford was around 50 rigs, whereas in its heyday (2011/2015), there were 250-280 rigs in operation (Figure 6.1.4). The rig count in Vaca Muerta is expected to drop from 11 to five rigs operating in the YPF/Chevron Loma Campana block in 1Q2016.[85]

Figure 6.1.4 Argentina (Neuquén) vs. USA: Comparison of Number of Operational Rigs



Reference: (1) US rig count on 31/12/2015: 698 (Baker Hughes).
Source: Neuquén Province Government, 2016 and Baker Hughes rig count, 2016.

As discussed previously, there are only two shale projects in the development stage in Argentina, and only recently producers have started to use horizontal drilling. YPF estimated that Loma Campana full field development is expected to produce 50,000 Bbl/day of oil and 3 MMm^3/d of gas by 2018, a much slower and modest development when compared to Eagle Ford.

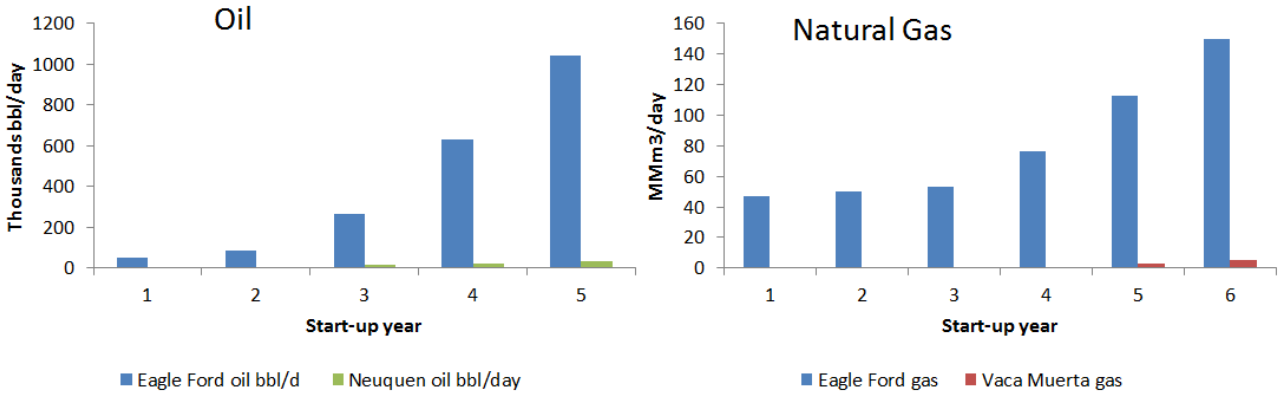
Comparing the development of Eagle Ford and Vaca Muerta from starting year 1 to year 6, respectively 2008/2013 and 2010/2015, there is a noticeable – and quite huge - difference in oil and gas production between the two formations, with Vaca Muerta much behind the US analog (Figure 6.1.5). In the year 2013 alone the operators invested USD 30 billion in Eagle Ford whilst the total investment in Vaca Muerta in the period 2010/2013 totalled USD 1.2 billion.

The first well drilled by Petrohawk in 2008 was already horizontal with 10 fracking stages. There were only 67 producing gas wells in 2009. In comparison, by the end of 2015 there were only 560 wells drilled on Vaca Muerta against more than 16,000 wells drilled on Eagle Ford in the same period.

In 2011, three years after start up Eagle Ford reached production of 265,000 Bbl/day of oil and 76.7 MMm^3/d of gas, with 1,052 wells completed (512 oil wells and 540 gas wells) and 150 rigs in operation.[86]

[85] http://www.argentinashale.com/es/noticias/exploracion-y-desarrollo/chevron-e-ypf-reducen-actividad-en-vaca-muerta
[86] (Texas Railroad Commission, 2016)

Figure 6.1.5 Vaca Muerta vs. Eagle Ford: Evolution of Oil and Gas Production after Start-up



Source: Adapted from Texas Railroad Commission, Neuquén Province Government and YPF.

Well productivity is higher on Eagle Ford, with IHS reporting the following comparative volumes for horizontal wells, based on Vaca Muerta historic production on 35 horizontal wells and Eagle Ford's 14,000 wells (Table 6.1.3):

Table 6.1.3 Eagle Ford vs. Vaca Muerta: Average Horizontal Well Production

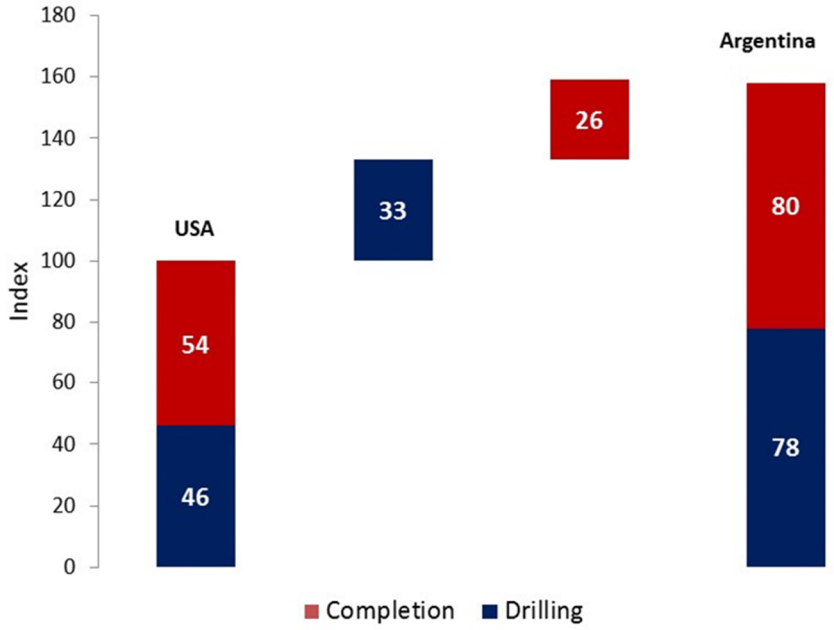
Month	Production (boe/day)	
	Eagle Ford	Vaca Muerta
1	600	520
6	300	200
12	200	120
21	120	100

Source: (IHS, 2016)

The figures for Vaca Muerta are likely to improve, as YPF and the other operators enhance drilling procedures and increase the number of horizontal wells.

According to industry specialists, the cost of drilling and completing a well in Argentina is 60% higher than the cost in the US, with drilling contributing to a slightly larger portion of the excess costs. Lower rig productivity, higher fracturing costs, higher local costs, labour strikes and labour related interruptions, weather conditions are some of the factors which contribute to the cost differential (Figure 6.1.6).

Figure 6.1.6 Argentina vs. USA: Comparative Unconventional Oil and Gas Well Drilling and Completion Costs Q3 2015



Source: Adapted from Shell/IAPG Conference Houston, 2016.

The number of companies actively involved in operations is an important factor in fostering the production of unconventional oil and gas. There are currently over 200 active operators in the prospective area for the Eagle Ford shale[87], a combination of small, medium and very large companies, whereas in Vaca Muerta there are less than 30.

The successful development of shale resources in the USA can be credited to the following factors:

- Technology innovation leading to the development of horizontal drilling and hydraulic fracturing, driven by government R&D programs, tax credits and private entrepreneurship.
- "Factory drilling" approach, based upon standardisation and the drilling of a large number of horizontal wells (5-20) from a single pad. This approach also allowed a more efficient procurement model based upon buying consumables such as chemicals, pipes and connections in competitive conditions.
- Initial "trial and error" approach for the drilling of wells justified by the need to drill faster and cheaper, without a detailed analysis of the geological characteristics. Therefore the large numbers of successful wells would finance the failed wells.
- Availability of drilling equipment. According to (Charlez, 2014), there were 2,000 drilling rigs in the USA out of a total 2,500 drilling rigs worldwide.
- Favourable fiscal regime where the landowners own hydrocarbon rights, thus encouraging the lease for shale exploration and development.

[87] See http://eaglefordshale.com/

- Attractive gas prices in mid-2000, contributing to the profitability of the shale projects. When gas prices went down and disconnected from international oil prices, US producers swiftly moved to oil and wet gas prone areas.
- Innovative use, treatment and recycling of water. According to CambridgeIP, a company specialising in global patent research, nearly 700 patents relating to water treatment for the hydraulic fracturing process have been filed by early 2011[88].
- Development of shale resources was undertaken by a large number of independent, nimble, lower cost producers, widely funded by financial institutions as opposed to conventional large scale projects, dominated by oil and gas self-funded majors.
- Availability of water resources played a key role in the USA, as water is essential for fracking.
- Vast knowledge of the geology gained by decades of onshore operation and the drilling of millions of wells. In 2014 there were 1.7 million active oil and gas wells in the USA[89]. The Energy Information Administration reports a total number of 514,768 gas producing wells in 2014[90]. According to IHS there are 4.5 million well records since 1859[91].

The shale producers in the USA, have been operating in a factory mode for nearly a decade, and are continuously looking for efficiency gains to counter the decline in oil and gas prices. Continuous CAPEX deployment and fast-moving well completions are key drivers for the development of shale in the USA.

In the USA the shale revolution was led by mid-sized independent companies, geared by significant level of debt. When oil prices dropped the financial institutions continued to provide credit, despite some recent bankruptcies suffered by highly indebted operators.

Argentina has very few medium-sized independent companies, credit is scarce and expensive, and shale is being led by state owned (YPF) and major oil and gas companies, which - in comparison with the independent operators - are known for longer decision making processes and a larger cost basis.

Another substantial difference between the US and Argentine cases arises from subsurface ownership, which is private in the first case and public (provincial) in the second. As a consequence, the “partnership” relationship with land owners is significantly distinct in both countries.

6.2 Timing and doability: The Argentine case

The production of unconventional gas is already a reality in Argentina, with tight-sand gas currently taking the lead, accounting for a quarter of the Neuquén basin’s output. The incentivised gas pricing programme (“Plan Gas”) was a key factor to move forward the development of tight sands gas, coupled to Argentina’s experience in fracking less permeable sand rocks since the 70’s. Over the years the oil companies operating in Neuquén have been producing small amounts of tight sands gas complementing their conventional gas production.

In addition to its world-class resources, Neuquén is advantaged vis-à-vis other unconventional areas worldwide due to the following:

- The area is crossed by three rivers (Neuquén, Colorado and Limay), although only the southern blocks crossed by the Neuquén River (Loma Campana, Fortín de Piedra) are able to use surface water for their projects; other zones might need to drill water wells, subject to prior provincial authorisation.

[88] (Taylor, 2013)
[89] https://www.fractracker.org/2015/08/1-7-million-wells/
[90] https://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm
[91] https://www.ihs.com/products/us-well-data.html

- It has very low population density.
- It is well connected regionally and nationwide.
- It is flat land with little vegetation.
- All the major oil companies have established operations in the province.
- It has a skilled labour force, experienced in oil and gas projects, albeit lacking some shale gas experience.

From a resource and regional point of view, the development of unconventional oil and gas is doable. However, the timing to develop commercial scale shale oil and gas in Argentina might be much longer than in the USA. There is an expectation from industry players that shale resources will be fully developed only after the first half of the next decade.

As in the USA, oil and gas prices play a major role in the economics of shale and tight sands gas projects. In addition, the current government incentivised producer prices do not seem to be sustainable against weak global oil prices and subsidised end-user prices in the domestic market.

In Argentina there are still geological and productivity risks to overcome, because there are only a few pilots and few horizontal wells in place, which poses limitations for a better understanding of the rocks. Most of the wells (vertical and horizontal) were drilled in Loma Campana, with vast tracts of Vaca Muerta still under-explored.

The learning curve in Argentina is still in its infancy, and it will take some time to find out the location of the prospective areas ("sweet spots"), enhance productivity and reduce drilling and completion costs. Therefore, the timing for full development of tight sands gas and shale resources is expected to gather momentum after 2020 and mature towards the end of the next decade.

As seen in Section 5, there are also other considerable issues to be addressed such as labour, equipment, materials and services, as well as logistics bottlenecks, to allow for the full unconventional production.

Unlike the USA, Argentina is impacted by rigid union regulations; lack of economies of scale; bureaucratic processes to import goods and services; and complex logistics.

In the meantime, the industry is making progress in reducing costs and improving productivity, for example:

- YPF and Chevron are increasing the number of horizontal drains and the number of stages, resulting in enhanced wells performance. The horizontal well LLL-992 drilled in 2015 is the highest productivity well on Vaca Muerta, achieving peak production of 1.63 thousands bbl/day[92].
- In March 2016, Pan American Energy has achieved a 70% time reduction in the drilling of tight sands gas wells, which coupled to new model contracts has reduced well costs by 53% since 2014.
- Total Austral reported significant reduction in drilling and completions time and cost on its Aguada Pichana pilot project, with wells best in class vs. US Haynesville development wells.
- In 2016 the IAPG and the Geological Association of Argentina launched the "black book" of Vaca Muerta (Transecta Regional de la Formación Vaca Muerta: Integración de sísmica, registro de pozos, coronas y afloramientos) the result of the unprecedented collaboration of Chevron, Exxon Petrobras, Roch, Shell, Tecpetrol, Total, Wintershall, YPF, LCV, Madalena, Medanito and Pan American Energy. The collaboration aims to reduce subsurface uncertainty through a better understanding of Vaca Muerta geology.

[92] (Spies, 2016)

In the USA, there is sufficient pipeline capacity in the Gulf Coast to transport shale gas and oil to domestic and international markets. In the north/northeast, a capacity shortage caused producers to use trains to transport liquids; subsequently gas pipelines were built to transport gas from Marcellus to east coast Canada and US 48-lower states.

As mentioned, in the Neuquén basin there is approximately 20 MMm^3/d of spare transmission capacity available for the domestic market and 10 MMm^3/d for exports to Chile. The existing infrastructure should be sufficient to evacuate unconventional gas from Neuquén until at least 2020. After that it would be necessary to add capacity, unless conventional resources were to decline faster than expected.

7. Conclusions and insights

This paper has assessed the status and prospects of unconventional gas development in Argentina, taking into account the country's gas market context and the key enablers and lessons derived from the US experience.

This section summarises certain main findings, as well as the authors' views on possible key drivers for unconventional gas development, considered critical to unlock its potential as a "game changer".

7.1 Main findings

Argentina's gas market context

Argentina is a mature gas economy and natural gas is widely used and accepted as a fuel of choice. International and domestic upstream players have been investing in the country for many decades, and the prolific Neuquén basin - comprising most of the country's unconventional gas resources - has a comprehensive gas transmission and road infrastructure.

Since 2003, governmental policies characterised by strong interventionism and "artificial" energy pricing have resulted in a sharp decline of domestic (oil and) gas reserves and production, and have created a widening demand/supply gap as well as an increasing dependency on imported gas and liquid fuels. The latter became an important catalyst for the development of indigenous natural gas resources.

Current and expected development of unconventional gas

Argentina is a country blessed with significant unconventional gas resources. According to the US Energy Information Administration (EIA), risked shale gas in place is estimated at 802Tcf, and it also possesses world-class plays, the largest of which is the well-known Vaca Muerta ("Dead Cow") formation. Argentina also has important tight-sands gas resources.

Some of these unconventional gas resources have already been transformed into reserves and production. In 2015, unconventional gas production reached 235.5 Bcf (6.7 Bcm), accounting for 15.5% of the country's total production, almost 73% of which was from tight-sands gas.

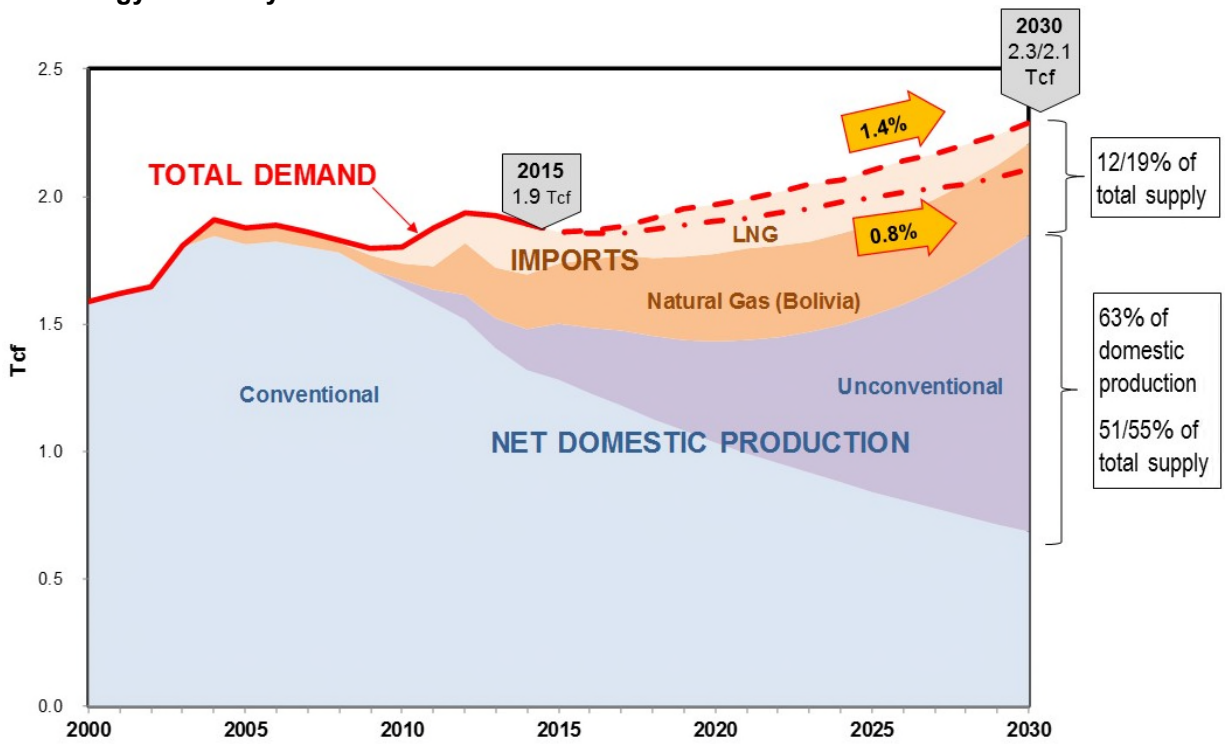
Vaca Muerta shale oil and gas has large potential, but requires continuous and significant investment. Shale production in Argentina is still in its early infancy stage, despite the efforts and steady progress already made by YPF and its partners (particularly, in Loma Campana), as well as by other local and international companies.

Until recently, Vaca Muerta has been mostly an oil story, and less of a gas story. The majority of the shale pilots and development activity on the formation has focused on oil prone areas. According to YPF, the Loma Campana full field development is expected to produce only 3 MMm^3/d (1.1 Bcma) of gas (and 50 Bbl/day of oil) spread over 1,500 wells. For unconventional gas to reach large scale development, in addition to the growing tight-sands gas ventures and production, it will be necessary to deliver more shale pilots and investment in the dry/wet gas zones.

Unconventional gas has the potential to become a "game changer", as Argentina's resources seem to be rich and large enough to meet most of the country's needs.

According to a long term forecast exercise performed by the authors, summarised in Figure 7.1.1, in 2030 unconventional gas is expected to contribute 63% of Argentina's total gas production - around 90 MMm^3/d (33 Bcma or 1.2 Tcf) -, as conventional gas continues to deplete. Argentina is expected to continue importing natural gas from Bolivia and/or LNG to meet 19% of its 2030 gas demand, in the "Business as Usual" scenario, and 12% in the "Renewables and Energy Efficiency" scenario.

Figure 7.1.1 Argentina: Total Gas Supply / Demand Balance - Business as Usual vs. Renewable and Energy Efficiency Scenarios



References:
Net Domestic Production: Excludes gas flaring.
LNG: Liquefied Natural Gas. Includes direct imports (Escobar and Bahía Blanca) and "indirect" imports (through Chile and Uruguay).
Source: Author estimates.

Table 7.1.1 compares the expected evolution of domestic and imported natural gas supply by sources, for the above-mentioned scenarios, highlighting the average annual growth rates from 2015 onwards.

The domestic production forecast is similar for both scenarios. After 2025, unconventional gas would outplace conventional gas as the first indigenous source of supply. Even if tight-sands gas would contribute higher volumes throughout 2016/2030, the production of shale hydrocarbons should show a more dynamic growth.

Under the Business as Usual scenario, in 2030 Bolivian gas/LNG imports would still amount to 34 MMm^3/d (12.5 Bcma or 0.44 Tcf), whereas in the Renewables and Energy Efficiency scenario such imports would account for 20 MMm^3/d (7.3 Bcma or 0.26 Tcf). The forecast assumes that Bolivian supply would continue to play a "base role", even after the expiry of the existing contracts - in 2027.

However, this will largely depend on how much gas Bolivia will produce post 2020, and how much it will deliver to its own domestic market and export to Brazil. The current Bolivian reserves do not seem sufficient to meet Argentina's needs; therefore, LNG imports will continue to play an important balancing role, and may eventually be higher than estimated in both scenarios.

The above-mentioned forecast implies that Argentina would increase unconventional gas production 5-fold between 2015 and 2030. If this does not happen, the need for imported LNG would increase, including imports of regasified LNG from Chile and possibly Uruguay.

Table 7.1.1 Argentina: Gas Supply Forecast, by Source - Business as Usual vs. Renewable and Energy Efficiency Scenarios

Gas Supply Sources		Business as Usual Scenario (Tcf)			Renewable and Energy Efficiency Scenario (Tcf)		
		2020	2025	2030	2020	2025	2030
Imports	LNG	0.2	0.2	0.1	0.1	0.1	0.0
	Natural Gas (Bolivia)	0.3	0.4	0.4	0.3	0.4	0.3
	Total Imports	**0.5**	**0.6**	**0.4**	**0.5**	**0.5**	**0.3**
Net Domestic Production	Shale Gas	0.1	0.3	0.5	0.1	0.3	0.5
	Tight Sands Gas	0.3	0.4	0.7	0.3	0.4	0.7
	Conventional Gas	1.0	0.8	0.7	1.0	0.8	0.7
	Total Production	**1.4**	**1.5**	**1.9**	**1.4**	**1.5**	**1.9**
Total Gas Supply		**2.0**	**2.1**	**2.3**	**1.9**	**2.0**	**2.1**

References:
Net Domestic Production: Excludes gas flaring.
LNG: Liquefied Natural Gas. Includes direct imports (Escobar and Bahía Blanca) and "indirect" imports (through Chile and Uruguay).
Source: Author estimates.

The substantial increase in unconventional gas production would require investing USD 73 billion for the drilling of 9,800 wells in the period 2016/2030. The expansion of the gas transmission and distribution networks would require an additional USD 25 billion, according to a study published by the Argentine Oil and Gas Institute (IAPG) in July 2015.

Indeed, Argentina's current structural hydrocarbon demand/supply imbalances, and the lack of cheaper imported options, call for strongly stepping up the investment in domestic gas exploration and development. But low international oil prices impact the investment strategy of the oil and gas players, and slow down the pace of unconventional play development, in particular shale resources whose breakeven prices are higher than current oil and imported gas/LNG prices. Whereas - in most cases - tight-sands production costs are reasonably competitive - at approx. 4.0-5.5 USD/MMBtu - shale gas costs still pose a major challenge - at levels estimated between 5.5 and 9.0 USD/MMBtu[93]. Such a challenge will require significant reductions in well costs, ideally targeting USD 4-5 million for vertical and USD 6-7 million for horizontal wells by 2030.

Several players concur that - at the current international oil prices - the production of shale resources may not be economically viable before 2019-2020. Other industry sources highlighted their view that - despite a large number of wells drilled in the area, and the successful outcome of Loma Campana - the feasibility of Vaca Muerta as a whole has not yet been fully proven.

This paper demonstrates that the development of unconventional gas is of utmost importance for Argentina to counter its declining conventional gas production and reduce its dependence on imports. However, the price of domestic gas should become more competitive with imported gas from Bolivia and LNG, which is not currently the case.

[93] It is worth noting that a recent news release from Wood Mackenzie estimates that the most expensive tight sands gas wells in the basin (Mulichinco horizontal and Punta Rosada vertical wells) break even at or below the government incentivised gas price of 7.50 USD/MMBtu.

Overall, in the eyes of public opinion the shale development programmes have considerably slowed down in 2016, with a palpable reduction in rig counts and working crews. After a quite uplifting 2015, the industry players are considering their options whilst waiting for the outcome of the Macri administration's pricing and fiscal policies. On the positive side, most of the oil and gas companies operating in Argentina are currently involved in unconventional projects; they have pledged hundreds of millions of dollars in pilots and future development activities.

Although the existing transmission infrastructure is considered sufficient to evacuate up to 30 MMm^3/d (1 Bcf/d) of additional natural gas injection in the Neuquén basin, it will be necessary to plan and invest in capacity expansion when unconventional production reaches this threshold.

Stakeholder view of favourable factors and key challenges

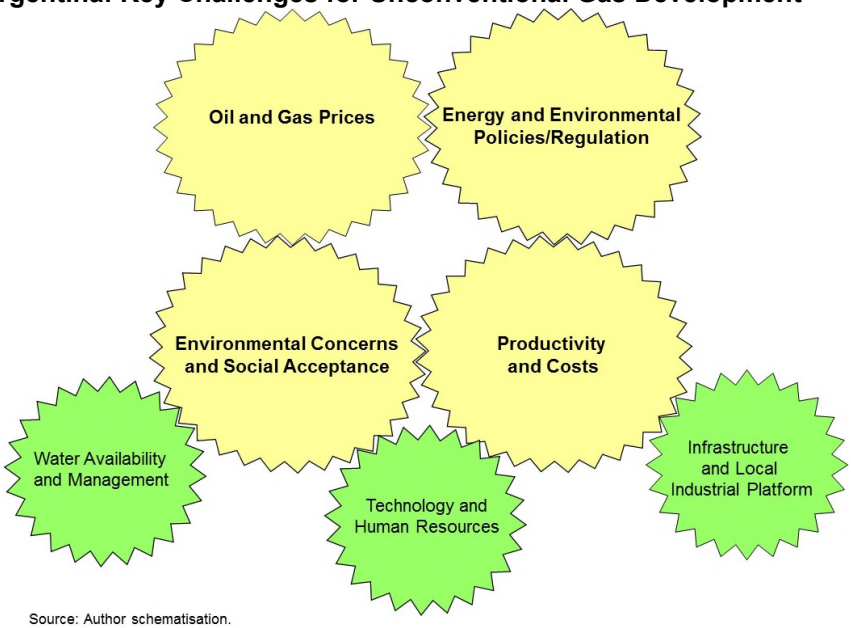
As mentioned in this paper, the research process included interviews with - and/or questionnaires completed by - representatives of governmental agencies, oil and gas companies, professional associations and NGOs, and consultation of individual experts.

When consulted about Argentina's potential to become a significant hydrocarbon producer in the next 5-10 years, the sources identified both favourable factors and challenges to be overcome. They agreed that Argentina has a relatively favourable "below surface" starting point for a potential large scale development of unconventional (oil and) gas, and that the most significant challenges to be addressed belong to the "above surface" dimension.

The favourable factors (or strengths) include: geological potential / resource play / quality of the source rock; geography / plain topography (flat land); low population density in operational areas; predominant role of gas in the energy mix / significant unsatisfied potential demand / demand vs. supply imbalance requiring incremental production; extensive oil and gas industry track record / local presence of the leading international oil and gas operators and service companies / skilled professionals and labour force / openness and eagerness to absorb and develop new technologies; available infrastructure / spare capacity in the gas transmission system; water availability (in overall terms and/or in some areas in the vicinity of rivers); new business environment; and attractive domestic gas prices (within the framework of existing incentive programmes).

The challenges were highlighted in different nuances; they were grouped by the authors under the following seven categories (see Figure 7.1.2): oil and gas prices; energy and environmental policies and regulation; environmental and social acceptance; productivity and costs; water availability and management; technology and human resources; and infrastructure and local industrial platform. The first four are virtually "go/no go" instances, whereas the last three pose conditioning factors that can either encourage or discourage unconventional (oil and) gas development, even in presence of favourable geological starting points and prospects.

Figure 7.1.2 Argentina: Key Challenges for Unconventional Gas Development



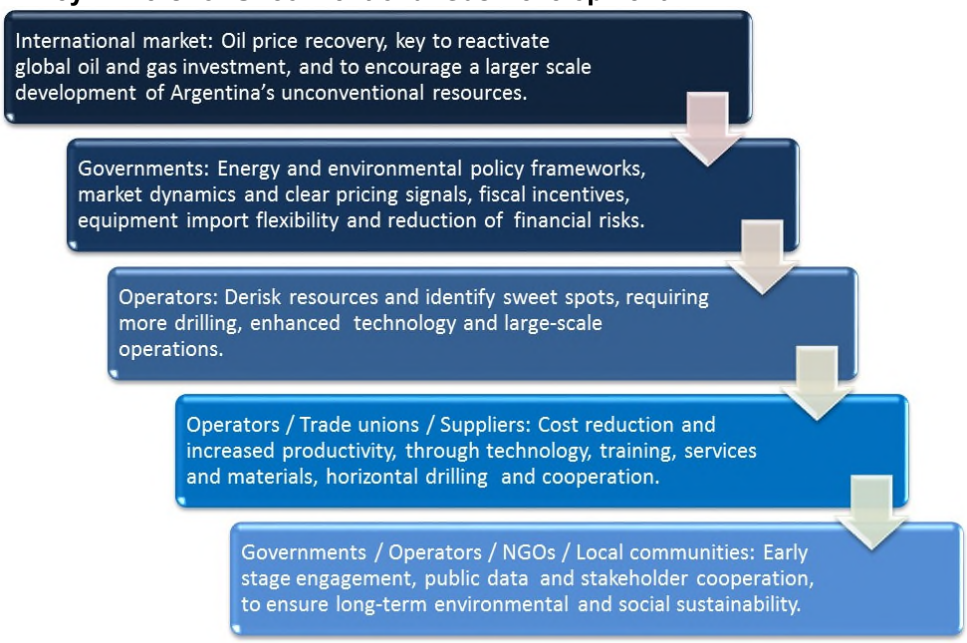
Source: Author schematisation.

7.2 Key drivers for unconventional gas development

Argentina has the possibility to become one of the most attractive unconventional (oil) and gas producing countries, but will need to overcome (some) "below" and (several) "above surface" challenges to fully develop its substantial resources.

Figure 7.2.1 summarises the authors' view of the key success factors for unconventional gas development in Argentina, which are further developed below.

Figure 7.2.1 Key Drivers for Unconventional Gas Development



Source: Authors own elaboration.

Improvement of the international market and investment context

At the international oil and gas prices prevailing in mid-2016, and despite the fact that domestic prices are temporarily decoupled and set at higher levels - in the short term the expansion of Argentine unconventional gas production will mostly come from tight-sands gas, whereas new investments in shale are likely to be kept at a minimum.

Higher incentivised prices are beneficial to boost domestic production, in particular for early stage unconventional gas/oil, but the competitiveness of Argentina's economy may be harmed if such prices are decoupled from international markets for a long while. Unless oil prices were to rise above 65-70 USD/bbl, international companies might need to slow down unconventional gas/oil investment in Argentina due to constraints in their global CAPEX budget.

National and provincial government agenda

The national and provincial governments play a critical role in the shaping of the future of unconventional (oil and) gas development. Examples of initiatives or measures that could have positive impacts are listed below.

- Provide clear medium and long term energy and environmental policy frameworks, ideally with an increasing level of coordination between national and provincial authorities.
- Encourage market dynamics and competition, facilitating the entry of new players.
- Provide clear signals in advance of future gas pricing mechanisms, and/or any proposed changes in the existing regulatory framework. The incentivised domestic gas price policy does not seem sustainable in a prolonged global low oil price scenario. Therefore, the authorities will have to focus on gradually removing end-user price subsidies to balance and design an acceptable transition towards deregulated gas and oil prices.
- Enhance fiscal terms, further differentiating unconventional from conventional (oil and) gas licensing.
- Simplify taxation and allow for flexible customs duties to cheapen the costs of testing new equipment and products, and facilitate imports of drilling rigs and hydraulic fracturing materials.
- Simplify dividend remittance procedures for investors (currently in progress).
- Agree labour market reforms - with the operators and trade unions -, with a view to increasing productivity.
- Reduce delays in the issuance of permits to use water in the Neuquén basin. It would be helpful to consider the possibility of "case by case treatment" for potential use of ground water (currently banned) suitable for fracturing operations, in those areas in which no irrigation or alternative uses can be envisaged.
- Enhance the level of cooperation and coordination between federal and provincial authorities to facilitate permitting and operations.
- Contribute to reduce financial risks. Despite the goodwill generated by President Macri's pro-investment agenda and the successful bond placement in April 2016, Argentina is still a high-risk investment country, finance is expensive and scarce, and investors would be seeking higher returns. Shale projects are capital intensive and require continuous investment to maintain production levels. Argentina's financial market is not yet prepared to provide credit for the development of unconventional oil and gas; as a consequence the projects have to be funded by companies' balance sheet and farm-outs, which do not address the funding needs of smaller operators.

Operator priorities

In order to be able to fully and economically develop unconventional gas in Argentina, operators need to focus heavily on the following agenda:

- Derisk the plays, through better understanding of the resources and sweet spots, by investing in exploration/delineation and pilot projects to reach factory approach as early as possible.
- Increase productivity by stepping up horizontal well drilling and increasing the performance of
- drilling teams.
- Develop innovative ways to reduce drilling, completion and water costs, in cooperation with service companies, governments and community stakeholders.
- Technology breakthroughs to overcome Vaca Muerta geological complexity.

Operator, trade union and supplier synergies

Cost reduction and increased productivity will only be achieved through increasing cooperation between operators, trade unions and suppliers (and the proactive support of governments).

Examples of priority areas are: development of a larger number of service suppliers, professional and operational staff training, improvement of logistics efficiency, and reduction of costs of services and materials.

Stakeholder cooperation between governments, operators, NGOs and local communities

Stakeholder engagement is absolutely key to ensuring environmentally and socially sustainable development of unconventional (oil and gas) ventures.

Even if the operators have devoted substantial effort and investment in community engagement, there seems to be significant room for progress.

One of the NGOs suggested that development plans should be designed at a regional or basin level, rather than by concession areas, and identified the following actions to ensure a lasting “social license”: (i) “compensation” for water volumes used during the hydraulic fracturing stages, by investing in the preservation of drinkable water (even in areas not directly affected by the operations); (ii) asset planning development oriented to minimise interference with other local productive activities, providing timely information on project start-up or relevant movements to the population; (iii) public disclosure of the number and location of wells drilled, and the volumes of water and types of chemical fluids used for drilling purposes (as done - through dedicated websites - by the US operators); (iv) “compensation” forf unavoidable environmental impacts (eventually in other locations), especially regarding land use and effects on biodiversity; and (v) close coordination with regional and local authorities, to ensure that the unconventional oil and gas activities will bring about infrastructure development benefits for the neighbouring towns.

Cooperation between operators and professional NGOs in some US states has been extremely helpful by providing more solid bases for unconventional oil and gas ventures. In Argentina, there is the additional challenge of supporting professional NGOs, while avoiding the interference of certain organisations that are merely fronting instruments for litigation purposes. It would therefore be very helpful if all “serious and well-intended” stakeholders - representing governments, operators, NGOs and local communities - engaged in more open and continued dialogue, for the benefit of all parties involved.

Six main pillars underpinned the US shale gas revolution: a favourable fiscal regime, knowledge of the subsurface, investment in research and technology, a full range of upstream players, political support and public acceptance.

When assessing these “pillars” for the Argentine context, it seems fair to conclude that the starting point is weaker - than in the USA - for the first four, and possibly quite robust for the last two.

As a concluding remark, it seems that unconventional gas has the potential to become a “game changer” in Argentina, but its large scale development will depend on the favourable combination of the key drivers identified above (and others that the authors might have involuntarily omitted).

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