



Unconventional hydrocarbons in Latin America

From dreams to reality

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Arthur D Little

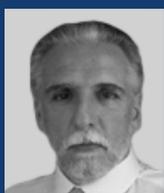
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Executive summary

Production of unconventional hydrocarbons became globally prominent in 2010, when the US, for the first time, reached a daily output of 1 million barrels of tight oil. In Latin America, where high unconventional hydrocarbon potential has been widely recognized, Governments noticed the need to attract experienced international operators, qualified suppliers and risk-prone investors to develop such resources. The current global low-prices and increasing social and environmental pressures raise questions about the timing of Latin America's unconventional take-off. This article anticipates that, notwithstanding the pitfalls, at least 1 mmbopd of new unconventional oil and gas production could come online in Latin America within the next 10 years.

There are enablers and challenges to be addressed to develop Latin American unconventional hydrocarbon resources efficiently:

- Benefit from the US's and Canada's development experience
- Encourage collective knowledge building and innovation
- De-risk reserves fast and efficiently
- Use advanced analytical tools selectively and fine-tune processes to attain outstanding results
- Assure sustainable operations and community support
- Secure market advantage

As conventional O&G production in Latin American countries such as Mexico, Colombia and Argentina approaches a decline phase, their unconventional O&G upside can be explored and developed, and serve to both increase overall hydrocarbon production and improve the trade balance. This is not only good news for their NOCs, but also offers ample opportunity for international E&P companies and service providers with appetites for and experience in unconventional production. However, the unconventional developments in the region will be subject to particular country level conditions and Argentina has taken the lead in developing large unconventional resources in Latin America, followed by Mexico and Chile, while Colombia still needs to overcome key challenges to relaunch exploration.

1. Introduction

Production of unconventional hydrocarbons became globally prominent in 2010, when the US, for the first time, reached a daily output of 1 million barrels of tight oil¹, together with nearly 20 Bcfd of shale gas. From then on, massive development continued to take place, until US unconventional oil production peaked at 4.5 MMbld in 2014. In the interim, global oil prices averaged over USD 90 per barrel. High prices motivated companies to invest strongly in proving the productivity and reducing technical risks.

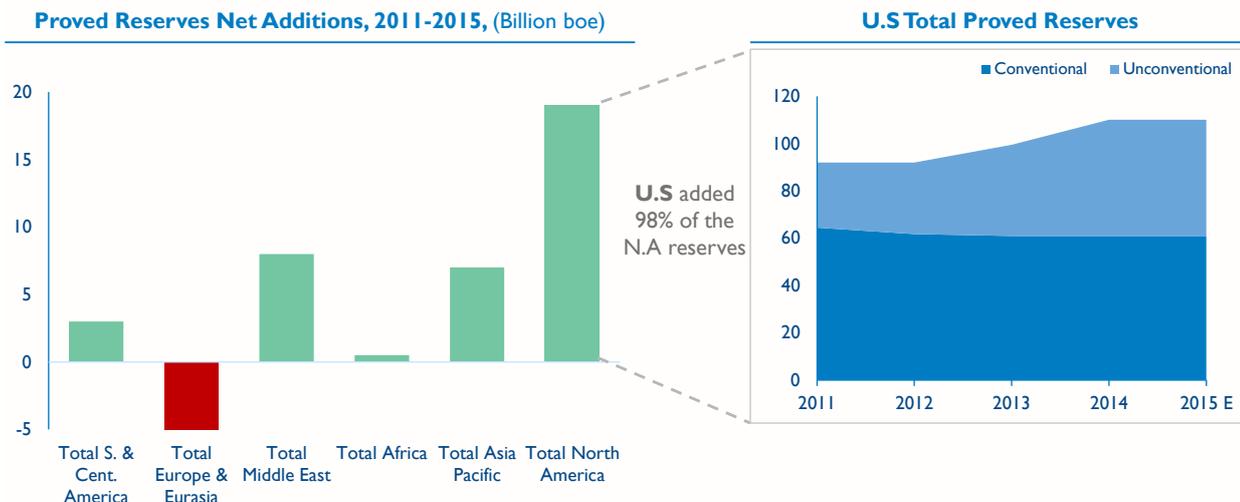
This US production ramp-up reshaped the global market with US unconventional reserve additions dominating the global industry over the last five years, as shown in Figure 1.

Ultimately, the expansion of the global oil supply caused oil prices to fall in late 2014. The price downturn challenged the economic feasibility of many unconventional development projects, but at the same time stimulated improvements in project competitiveness through innovation in development and production techniques, technologies, and management processes, as well as through industry consolidation. Today, the opportunities with superior productivity are profitable even at USD 40 per barrel, and the US industry continues to grow with the Permian Basin being in the vanguard.

Latin America’s high unconventional hydrocarbon potential has been widely recognized, especially in Argentina, Mexico, Colombia, and Chile. International researchers also estimate large unconventional resources in Brazil and Paraguay, too, but they are located in scarcely studied onshore basins. Shale oil potential in the Maracaibo Basin’s source rock has hardly been explored, eclipsed by Venezuela’s very large Miocene extra-heavy oil resources.

Governments in the region noticed the need to attract experienced international operators, qualified suppliers and risk-prone investors to develop unconventional resources, and some countries adopted policies to encourage such developments. But the pace has been slow and uneven region-wide. The current global low-prices and increasing social and environmental pressures raise questions about the timing of Latin America’s unconventional take-off. Notwithstanding the pitfalls, we believe that within the next 10 years at least 1 MMboed of new unconventional oil and gas production could come online in Latin America.

Figure 1: Global net proved reserves addition 2011–2015 (left), US oil and gas proved reserves (right) (EIA)



Source: Arthur D Little

¹ EIA defines tight oil as the oil embedded in low-permeable shale, sandstone, and carbonate rock formations.

2. Challenges for unconventional developments in Latin America

Figure 2: Fiscal and contractual incentives to promote unconventional hydrocarbon developments

Colombia	Argentina
<ul style="list-style-type: none"> 40% discount in royalties over the conventional rates Longer exploratory phase in E&P contracts (up to 13 years) Longer E&P contract duration up to 30 years (vs. 20 years for conventionals) 	<ul style="list-style-type: none"> 25% reduction in royalties (from 12% down to 8%) during 10 years, available till late 2017 Longer exploratory phase: 8 years in 2 periods, plus a potential extension of up to 5 years (vs. 6 years + 5 for conventionals) Exploitation term = 35 years (vs. 25 for conventionals), including a pilot project period of up to 5 years
Mexico	Chile
<ul style="list-style-type: none"> Authorities still working on the unconventional regime 	<ul style="list-style-type: none"> Preferential terms for unconventional projects can be included in current CEOP contracts, but the conversion process is not clear yet

Source: Government websites. Arthur D. Little Analysis

Latin American countries have tried different approaches for promoting investments in unconventional resources. Governments and local players were aware that the first factor in attractiveness was the size and quality of the resource base. They also understood that in this context, "quality" meant not only richness, concentration, maturity or rock properties, but also the extent to which all those attributes were known and understood so that reliable conclusions about cost, productivity and commerciality could be reasonably drawn. Then some countries focused on improving technical knowledge and invested in exploration, while others prioritized the appeal of the contract terms and incentives offered to private investors.

For example, Colombia was the first country in the region to approve preferential fiscal terms for unconventional developments, and offered unconventional areas in its 2012 bidding rounds. Argentina relied on its world-class resource base, and its progress towards unconventional developments has been gradual, and somewhat contradictory, but so far encouraging. It combined promotional efforts, pioneering investments, unconventional-specific regulations, partnering strategies and a recent move to market liberalization mixed with regulated or negotiated price incentives. In Mexico, Pemex took the lead in exploring and confirming the unconventional potential, but energy reform has only recently opened the

Figure 3: Characterization of unconventional activity

	Argentina	Mexico	Colombia	Chile
Prospective area, Formation (Basin)	30,000 Km ² , Vaca Muerta (Neuquina)	50,000 Km ² , Tithonian / Turonian (Tampico-Misantla, Burgos, Sabina-Burro-Picachos)	30,000 Km ² , La Luna (Valle Magdalena Medio)	10,000 Km ² , Springfield (Magallanes)
Technically Recoverable Resources	~ 15 Bn boe ~300 Tcf	~ 30 Bn boe ~140 Tcf	~ 5 Bn boe ~ 20 Tcf	~ 48 Tcf including both shale and tight gas
Area awarded for exploration and/or exploitation	~ 70% of the prospective area in 28 unconventional blocks (19 pilot-project exploitation concessions and 9 exploration permits) + ~ 40 conventional blocks that can be re-converted	~ 8,200 km ² (14 blocks)	~ 8,000 km ² (8 blocks)	~ 60% of the prospective area in 11 CEOPs + 2 direct ENAP areas that may need re-negotiation if moving to unconventional activity
Main players	YPF + its subsidiary YSUR; major oil companies, IOCs, foreign NOCs, key Argentine and Regional players	100 % Pemex	Ecopetrol; Exxon Mobil; Patriot; Conoco; Canacol; Parex Resources	Enap; ConocoPhillips; GeoPark; PetroMagallanes
Shale/tight wells drilled	~ 800 since 2010	~ 25 since 2011	-	~ 75 since 2012
Investments completed	~ 8,000 MM USD	~ 500 MM USD	Less than 100 MM USD	~ 500 MM USD
Future announced investments	~ 5,000 MM USD 2016-2020 announced	55 MM USD for 2016-2018	Environmental regulation for development pending	1,000 MM USD estimated next 5 years

Source: Government and companies' websites. Arthur D. Little Analysis

discussion about contract models and special regulations for unconventional developments. Interest in Chile's unconventional potential gained momentum a bit later, but its contract models can adapt to the new initiatives.

The different strategies, efforts, timing and local conditions have resulted in varied rates of progress in unconventional resource developments, as shown in Figure 3.

There are enablers and challenges to be addressed to develop Latin American unconventional hydrocarbon resources efficiently:

- **Benefit from the US's and Canada's development experience.** Each individual play has unique characteristics and differential issues to be addressed. Though the North American experience may not be fully replicable, it provides visible best practices for Latin America's unconventional development programs. At the time of peak activity in the USA, the "factory-drilling" paradigm prioritized adding production and minimizing rig-setup time. The price downturn produced a paradigm shift to models such as Statoil's "perfect well"² or Argentina's "super pozo," which focus on attaining premium well productivity by means of optimal drilling, completion and reservoir engineering designs. Well-after-well cost reduction and time shortening are still targeted and measured, but priority attention is also now paid to keeping rig count and resource exposure controlled, as well as to lowering the costs per produced barrel.
- **Encourage collective knowledge building and innovation:** Openness and cross-fertilization of the knowledge base is the shared responsibility of government agencies, unconventional oil and gas (O&G) operators and service and equipment suppliers – engaging both experienced international companies and established local players. An innovative collaborative atmosphere is needed more than ever in the prolonged price downturn.
- **De-risk reserves fast and efficiently:** The window of opportunity in which US unconventional resources were commercially developed allowed a broad margin for trial-and-error overspending. That window is no longer open. In the low-price cycle, Latin American developers need to understand the plays, prove well productivity and reduce well cost at higher speeds and lower spending rates.
- **Use advanced analytical tools selectively and fine-tune processes to attain outstanding results:** A new generation of optimal wells demands knowledge-based decisions to define and locate sweet-spots, premium-well areas within sweet-spots, horizontally navigable intervals within the formation, and selectively frackable stages along the horizontal section in order to, in the end, devise the most appropriate drilling, completion and stimulation techniques. A broad spectrum of disciplines and new technologies support decisions related to the longitudinal or transverse orientation of the horizontal well section; its length, incline and trajectory; the completion type; the number, spacing and reach of fractures; the tuning of hydraulic pressures; and the selection of relevant chemicals and proppants. Powerful analytical tools are available, but they must be used selectively in a context in which "razor-thin"³ economics do not allow unnecessary spending. Pilot projects are key for spatial clustering and drilling-campaign planning. To pursue wells that maximize recovery and production efficiency, feedback from operations needs to be made immediately available to the teams designing the next well.
- **Assure sustainable operations and community support:** A receptive natural environment and supportive communities are also threshold enablers, which constantly challenge all involved stakeholders to superior levels of responsibility. Governments must set both general and unconventional-specific environmental regulations - preferably upfront - , build a consensus, and become the key communicators of their countries' strategic decisions and the primary facilitators of stakeholder dialogue. Authorities at national, regional and municipal levels should align the information they convey to local communities, and mediate in order to enforce high social and environmental standards in operations on one side. On the other side they need to deter incidental coercion from less scrupulous pressure groups. Companies need to display strategies to proactively communicate their policies and create a strong link with local communities, not just as an image builder, but as an ethical end in itself. Non-governmental organizations (NGOs), unions, local representatives and social organizations need to play surveillance roles, but at the same time they should honestly seek solutions to let the activity progress in order to allow citizens to enjoy the benefits of an enlarged energy supply.
- **Secure market advantage:** Unconventionals flourished as an import substitution opportunity in the heart of world's largest energy-consuming market. Success in Latin America will also be tied to preferential access to domestic and neighboring markets, either due to *locational advantages* or because of *upstream-downstream integration forces* at NOC or country levels. The advent of shale oil will be a blessing for domestic refineries looking to replace region-wide light oil production decline. Conversely, in those countries that are more openly exposed to international competition, unconventional developments may be more vulnerable.

² Quoted by The Wall Street Journal on May 17, 2016.

³ Halliburton's *dixit*, as used in its commercial materials.

3. Where will large unconventional developments flourish in Latin America?

Argentina

- So far, Argentina is the only Latin American country in which unconventional production has started commercially, though it is still small relative to its potential.
- The Vaca Muerta formation is a large, concentrated and broadly known play, with large shale oil, shale gas and tight gas potential. It is the main source rock in the mature Neuquen Basin, which still accounts for 40% and 54%, respectively, of Argentina's conventional oil and gas production. There is a significant upside in overlying and underlying plays, as well as additional unconventional resources in other Argentine producing basins.
- Argentina issued specific license terms for unconventional hydrocarbons, including tight gas, in July 2013. Consistently, the Congress modified the Hydrocarbons Law in late 2014. Wellhead crude oil prices – set by a collective agreement between producers and refiners – stood above import parity in the downturn, but this benefit did not make a big difference for unconventional investment decisions, as it was never believed that it would be long lasting.
- A large part of the Neuquen Basin's prospective acreage was already licensed under conventional terms. License holders can now apply for block reclassification, in full or in part, and obtain unconventional licenses in exchange for specific work commitments. YPF and other established players have sought international partners to exploit these opportunities. Provincial bidding rounds, direct negotiations, and an active secondary market of petroleum interests provide dynamic access vehicles.
- The new government administration that took over at the end of 2015 removed all export restrictions, taxes and foreign-exchange controls, further liberalizing the economy. In 2016, Argentina's financial situation improved significantly after an agreement on conflicting foreign-debt hold-outs was reached.
- Available capacity at the Neuquen Basin's infrastructure and surface facilities provides a sunk-cost advantage. A strong service and equipment-supplier market is already established. The knowledge base is broadly available, and an intellectually open, collaborative and innovation friendly atmosphere prevails. Prestigious, industry-wide organizations serve as active networking platforms, and there is a busy agenda of industry events.
- Local authorities and populations are familiar with and supportive of the oil and gas industry. The industry itself has taken the lead in clarifying the most sensitive environmental issues about unconvensionals. However, no specific regulation has been promulgated so far, and unconventional exploration and production (E&P) is still ruled by the same norms as conventional activities.
- Vaca Muerta's light crude oil production will rise to fill the gap left by the rapid decline of El Medaniito conventional light oil from the Neuquen Basin. As the Latin American country with the largest penetration of natural gas in its primary energy matrix (around 52–54%), Argentina is a major net gas importer, too. The unconventional natural gas price that Neuquen Basin's producers get at the production delivery point continues to be set by the Government, and is independent from the opportunity cost given by the import parity for natural gas (a mix of pipeline and liquified natural gas import prices). To promote unconventional developments, a fresh new regulation has placed such price at a level that is clearly above import parity today, and declines slowly along time.
- Argentina has taken the lead in developing large unconventional resources in Latin America, followed by Mexico and Chile, while Colombia still needs to overcome key challenges to relaunch exploration. With almost 20 unconventional pilot projects and further exploration plans under way, Argentina is firmly moving towards its next more substantial development stage. Apart from the NOC YPF and the Province-owned GyP Neuquen, many top-rated operators and investors are engaged in these activities: major oil companies and large international oil companies IOCs (e.g. Chevron, Exxon Mobil/XTO, Shell, BP, Total), key Argentinean regional players, large national oil companies, Canadian independents and others.

Mexico

- Mexican resources are concentrated in three major basins: Sabina-Burro-Picachos (SBP), Burgos and Tampico-Misantla (TM). So far, the exploration and analysis of these unconventional plays have been conducted exclusively by Pemex. Geophysical conditions and productivity still need to be proved. After Round Zero, Pemex kept nine blocks with unconventional potential and is currently in the process of negotiating five other contracts under the service contract framework (CIEPs).
- Proximity to large unconventional developments in the US brings advantages in terms of knowledge and closeness to a specialized service market. Under the energy reform legislation, Mexican contract models are aligned with international standards. The 25% minimum national content required by 2025 is not deemed to be excessive if the domestic industry learns to leverage expertise from providers in neighboring US plays.
- The SBP basin is the geological continuity of Eagle Ford. Wells drilled by Pemex confirmed the presence of natural gas, but existence of liquids is still to be proved. For players with large acreage on the US flank and natural gas orientation, opportunities in SBP could represent a natural extension for their current operations. One key challenge will be to reach necessary cost-efficiency levels to compete with gas imports from the US, since Mexican prices are mainly indexed to Henry Hub. However, Mexico is still an LNG importer, and gas pipeline infrastructure expansion plans provide an opportunity to broaden the natural gas customer base.
- The hydrocarbons found in the Burgos basin consist mainly of wet gas and condensate, which offer attractive technical conditions for natural fracture flow. The area's remote location involves lower social risks. Burgos could be appealing to players interested in liquids and keen to accept higher technical risks in their search for material opportunities with high upside potential.
- Initial technical studies conducted by Pemex indicate high rock quality in terms of thickness and organic content, especially in the TM basin. These blocks are located in conventional oil producing areas, with easy access to oil facilities and infrastructure, as well as sufficient water availability. Potential investors in these opportunities should have expertise in enhanced liquid-recovery techniques, and

be capable of managing the social risks posed by proximity to communities.

- Declining crude oil production and growing natural gas demand provide key market incentives. As domestic petroleum production has fallen by about 30% in the last 10 years, Mexico urgently needs to add new barrels in the short and medium terms. Deepwater opportunities are highly prospective, but will not likely deliver significant production before 2022, so unconvensionals with shorter development periods could help mitigate the supply gap in the medium term.

Colombia

- Colombia pioneered the promotion of unconventional resources in Latin America and, in 2012, adopted a special regime to improve the economies of these types of resources. Currently there are six unconventional blocks contracted by ANH to Exxon, ConocoPhillips and other companies, but plans have suffered the double set-back of the price downturn and environmental controversy. As a result, exploration activities were delayed and unconventional drilling has been very limited.
- The estimated unconventional resources of Colombia in the Middle Magdalena Valley (MMV) are 5 billion barrels and 20 Tcf⁴. Technical studies, such as the one conducted by EIA with the support of Colombian operators, have highlighted the rock quality of La Luna formation. The prospective areas are oil-prone with a lower wet gas potential. However, La Luna presents substantial vertical heterogeneity and needs to be drilled and studied in further detail.
- MMV is a mature conventional basin where the availability of oil surface infrastructure and water resources provide additional attractiveness. In spite of the government's fiscal incentives, diverging stakeholder interests have raised tensions in the debate about the environmental impact of unconventional activities and the standards to be enforced. As a result, specific regulation for unconvensionals has only been completed for exploration activities, but not for field development operations.
- Ecopetrol's medium-term strategy no longer considers investments in unconventional developments. This apparent side-step of the NOC might discourage some international players willing to find local partners with extensive knowledge of Colombian geology and topography, as well

⁴ EIA, May 2013

as those with the experience to deal with local communities and security issues.

- The constrained road infrastructure in Colombia is one key challenge for large-scale unconventional operations. The national hydrocarbon industry is used to working with large tanker-truck fleets for heavy oil operations; however, most rural roads are not built for traffic as heavy as that required during massive fracking operations, and this will demand extra investments from operators.
- In sum, with still-high geological uncertainty and significant operational, logistical and environmental barriers, as well as challenging economics, we believe the development of unconvensionals in Colombia over the next decade is far from secured. To speed up and implement the environmental regulation, as well as to attract the investments needed to confirm the potential of unconvensionals, a strong commitment from the government is required. Colombia's hydrocarbon sector has traditionally been open and friendly to international players, but additional efforts from the stakeholders are required to incorporate unconventional production into the country's supply portfolio.

Chile

- Chile has recently joined the group of countries with recognized unconventional hydrocarbon prospectivity in the region. As early as 2005 ENAP, the Chilean NOC, coined the concept that very large volumes of gas had to be trapped all across the Magallanes Basin, which extends onshore across the South end of the continent and the Island of Tierra del Fuego, as well as offshore in the interjacent Magellan Strait. However, for several reasons, commercial conventional discoveries have not been declared. The idea was later revisited using unconventional approaches and technologies, and giving rise to further optimism.
- Significant unconventional gas potential has been identified in the Springhill Formation, the source-rock of Chile's Magallanes Basin, and its foreland continuation in Argentina, the Austral Basin. Additional gas potential is deemed to lie in tight Springfield reservoir rock. This potential has encouraged the Chilean government to promote the exploration of unconvensionals in Magallanes, led by ENAP.
- In the 1970s, Chile created the figure of the "Special Operating Agreement" (CEOP), by which private companies can hold contract rights on E&P blocks, risk capital investments and, if successful, earn in compensation the

right to be paid in cash or in the form of a freely marketable share in production.

- The Magallanes Basin lies in the XII Region in the South of Chile, and is an oil, gas and petrochemicals pillar of the regional economy. A developed supplier market provides related conventional services and materials. ENAP itself runs terminals, gas processing plants and major maintenance facilities. The XII Region is distant, but can be approached by ship and counts with good industrial harbors.
- Scale and locational advantages to attract international fracking and services companies may clearly emerge if Chile and Argentina cooperate to develop unconventional resources on both sides of the bi-national basin. On the Argentine side, unconventional hydrocarbon potential (mainly gas) has been identified in shales of the Springhill Formation and some of its upper and side members. Both countries are strongly linked in terms of industry culture, integrated land and marine logistics, presence of private players on both sides of the border, and cooperation and partnering between their NOCs.
- Local authorities, communities and unions are strongly supportive of the presence and expansion of the petroleum industry in the XII region. On the other hand, environmental organizations have made public their concerns about fracking in Central-Western Tierra del Fuego island, a natural land with sparse human settlements. The prevailing feeling of the population is favorable, but neither specific environmental regulations nor a management guide have been published in Chile yet, as they were for renewable energies and other industries.
- Substitution of hydrocarbon imports is a strong economic motivator for domestic production. Chile imports circa 96% of its refinery feedstock and 80% of the natural gas it consumes.
- The price downturn and poor exploration results have had an impact on conventional exploration activity. Investment plans have decelerated, and some blocks were either relinquished or taken over by ENAP. However, eleven CEOPs are still moving forward, with GeoPark and New Zealand's Greymouth as key players, together with several non-operating partners. Besides partnering in many of those CEOPs, ENAP is investing heavily in exploration in its own blocks, with a strong unconventional focus. In 2016, ConocoPhillips farmed in ENAP's Coiron block, targeting unconventional prospecting and drilling.

Conclusions

As conventional O&G production in Latin American countries such as Mexico, Colombia and Argentina approaches a decline phase, their unconventional O&G upside can be explored and developed, and serve to both increase overall hydrocarbon production and improve the trade balance. This is not only good news for their NOCs, but also offers ample opportunity for international E&P companies and service providers with appetites for and experience in unconventional production. However, the unconventional developments in the region will be subject to particular regional conditions and specific country level challenges:

- Latin American unconventional resource holders are expected to operate in a scenario of intensified competition between different energy sources – including, but not limited to, all hydrocarbon and deposit types – with the perspective of a long-term, changing demand mix. Consequently, they should not keep waiting for a spectacular price rebound, but get ready to compete at flatter, slowly growing, acid-test prices.
- The conditions are set for extensive development of unconventional resources in Argentina. Meanwhile Chile and Mexico still need to confirm the productivity and economic feasibility of their plays, while the prospects for Colombia remain uncertain.
- Majors committed to unconvensionals, resilient North American E&P niche players, and Latin American independents with long histories of success in the region can be counted among the investors ready to join host NOCs with solid domestic positions in the Latin American unconventional adventure.
- We expect production to grow in Argentina over the next five years to reach a large scale in the early 2020s. We expect something similar to happen in Chile and Mexico over a longer period – for instance, the next 10 years, provided, in all cases, that oil prices do not drop below \$50/Bbl.
- The four countries we analyzed are in great need of crude oil supply. Unconventional resources are positioned to become mid-term sources of light oil feedstock to their domestic refineries.
- Natural gas has emerged as transition fuel for a low carbon future. The share of natural gas is expected to continue expanding into the world's primary energy matrix, and domestic markets in Latin America are following this trend. Large gas consuming countries as Argentina and Chile have a strong business case to develop unconventional gas soon, since LNG or natural gas imports have a strong negative impact in their foreign trade and foreign currency balances.

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