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India is positioned alongside countries with complex relationships. How the natural gas market in India evolves depends as much on project economics as these relationships. The author assesses ways for India to navigate these challenges to secure a growing natural gas market.

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Vaca Muerta in Argentina, Bolivia Reserves and the Brazilian Pre-salt: How to Organize All of This Gas to Brazil's New Natural Gas Market?

Fernanda Delgado and Daniel Lamassa – FGV Energia

Natural gas is increasing its importance in the world energy matrix, as it is an energy vector with lower greenhouse gas emissions, nonetheless, it is still fossil energy. It is known as a transition fuel for a less carbon-intensive matrix, and Brazil can take advantage of its pre-salt natural gas reserves from both an economic and environmental point of view.

In addition, the opening of the Brazilian gas market raises the discussion of its potentially available natural gas, whether from national production or imported. The idea of possibly having a large amount of available and affordable gas for the country sounds interesting from a practical point of view and intriguing from the economic point of view.

The more that these discussions are on the table, the information asymmetries lowers, which leads to the possibility of reducing transaction costs. The *Novo Mercado de Gás* (The New Gas Market, in Portuguese) is a new Federal program that aims to promote competitiveness, integrate the industry with the electricity and other industrial sectors, harmonize the federal and state legislation and remove tariff barriers. The challenge is to introduce policies that increase efficiency so that higher volumes of gas get to market. In Brazil, the increase of the offered volume is related to fomenting the risk appetite and reducing inefficiencies along the entire production chain. Regarding the imported gas, the challenge is based on strategic analysis of the price at which the molecule arrives in the country versus the national production cost.

In this scenario, it is appropriate to evaluate all the possibilities of available natural gas supply to the Brazilian market. The closest alternatives to the domestic supply coming from the pre-salt are the renewal of the supply contract with Bolivia, as will be discussed later, even for smaller volumes, the possibility of buying gas from Argentina, now an exporter since Vaca Muerta's play exploration success.

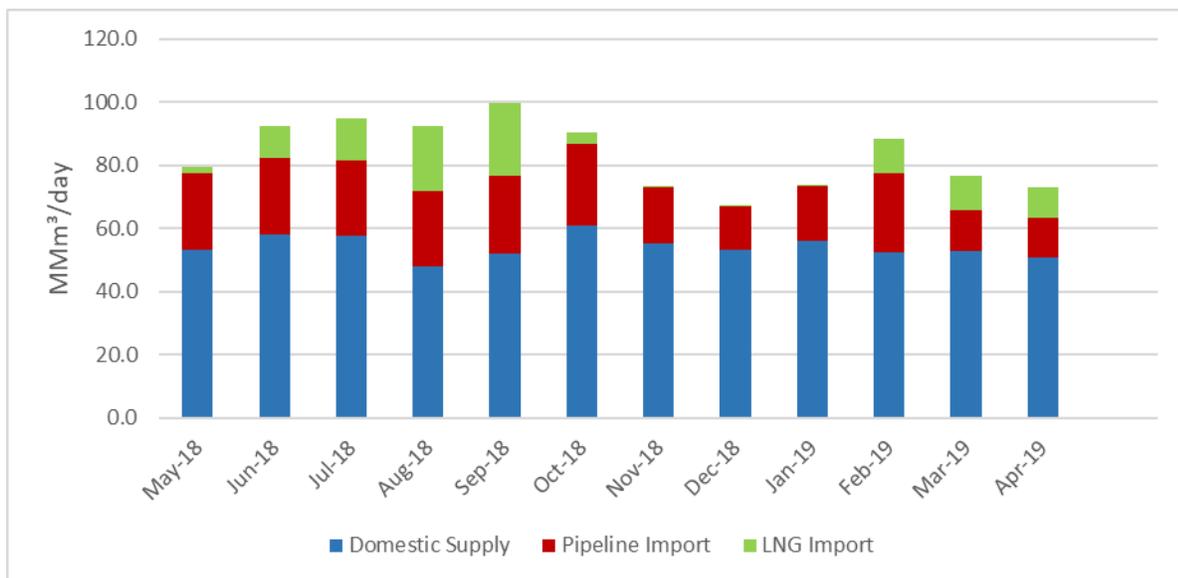
Table 1: Comparison Between the Plays – Vaca Muerta, Bolivia and pre-salt

	Vaca Muerta's shale gas	Bolivia's gas	Offshore pre-salt's gas
Actual Production	27 MMm ³ /d	50,94 MMm ³ /d	68,7 MMm ³ /d
2018 Production	28 MMm ³ /d	54,44 MMm ³ /d	55 MMm ³ /d
Production Projection for 2020	43 MMm ³ /d	46,56 MMm ³ /d	110 MMm ³ /d
Proven Reserves	8,721 tcm	0,3 tcm	0,205 tcm (proven) / 0,360 tcm (potential)

Source: Prepared by the authors using data from EIA, BP, ING, GyPNqn, MME and ANP, 2019

Table 1 compares the main indicators of the three plays of this analysis: Vaca Muerta in Argentina, Bolivia’s natural gas reserves and the Brazilian pre-salt. It is possible to observe that there is a big difference between the 2018 production and the 2020 production projections. While Bolivia’s production is projected to fall, from 54 to 46 MMm³/d, pre-salt and Argentina’s shale natural gas production tend to rise, from 55 to 110 MMm³/d and 28 to 43 MMm³/d, respectively. Figure 1 shows the variation in the supply of domestic and imported natural gas, between May 2018 to April 2019, covering the Brazilian produced natural gas, the imported from Bolivia and the import of LNG.¹

Figure 1: Domestic and imported natural gas supply (in MMm³/day)



Source: Prepared by the authors using data from the MME

**Vaca Muerta—
Argentina**

Gas from Vaca Muerta in Argentina could make the country one of the top natural gas exporters in the world, for the size of its reserves, with a potential volume of 8.7 tcm (trillion cubic meters) (Table 1), considered the second biggest unconventional gas reserve. However, the oil industry acting in Argentina has been struggling with several difficulties, some inherent to hydraulic fracking – and its cost, and others to the outflow of all-natural gas that is being or may be extracted in the future.

The lack of infrastructure affects the project operation and is one of the reasons for the high cost of production when compared to the United States shale gas production. Estimates show that the drilling cost of a shale gas well in Vaca Muerta is US\$ 7 million, while in the American shale the cost is US\$ 6 million. The project breakeven is US\$ 40 per barrel and US\$ 6 per million Btu (British Thermal Unit) for gas.²

There are enterprises that are being affected by the lack of sand, as an example, essential material for fracking, because there is no sand mine near Vaca Muerta, while in other enterprises the issue is related to the lack of specialized labour.³ The inefficient infrastructure for the project’s size – and flow – affects the outflow of the natural gas as well, as Vaca Muerta is 1200 kilometres away from the country’s capital, Buenos Aires, however a gas pipeline to the city is projected⁴, costing US\$ 1.8 billion, being able to flow 40 MMm³/day⁵.

On the consumption side, the Argentine domestic market does not consume all of its gas produced, creating possible export opportunities. Argentina has a strategic geographical location to export natural gas. It is noteworthy that in June 2019 YPF⁶ loaded its first ship carrying LNG from Vaca Muerta with a capacity of 30.000m³ (the destination of the gas was not revealed⁷).

With the necessary investment, of approximately US\$ 120 billion by 2030, Argentina will have the potential to produce and then export⁸. According to the Argentine company Tecpetrol, the

country will no longer need to import any natural gas in the coming years, either by LNG or gas pipeline, but to export 85 MMm³/day in 2022 and increase to 95 MMm³/day by 2027, with the estimated cost of US\$ 2.5 / MMBtu (Tecpetrol, 2019).

Both Brazil and Chile, will be able to take advantage of this cheap gas from Argentina, and Argentina's low demand for the Bolivian gas. This allows Brazil to be able to import larger volumes of this idle gas – also for lower prices from Gasbol⁹.

Another alternative, is the Southern states of Brazil that may import natural gas through the already existent TSB (Transportadora Sulbrasileira de Gás S.A.) pipeline, which transports natural gas from Argentina to the Uruguiana gas-fired powerplant, in the Rio Grande do Sul. According to the Chairman of the Argentine oil company YPF, Miguel Ángel Gutiérrez, another alternative could be “that Brazil could sell more electricity to Argentina, through stored water, and receive more gas in exchange”¹⁰.

Bolivia

Because of their proximity, in 1999 Bolivia and Brazil created the Brasil-Bolívia gas pipeline (Gasbol), connecting Bolivia to the Midwest and South in Brazil. The gas pipeline is divided into two parts, the Bolivian part is owned by GTB (Gas TransBoliviano), being controlled by YPFB (*Yacimientos Petrolíferos Fiscales Bolivianos*) and the Brazilian part is owned by TBG (*Transportadora Brasileira Gasoduto Bolívia-Brasil S.A.*), having Petrobras (through Logigás) as the major shareholder, with 51% of the shares. According to Moraes (2019¹¹), there are four types of transportation contracts with TBG:

- Transportation Capacity Quantity (TCQ) – it is a firm natural gas transportation contract of the take-or-pay type, which would initially provide 8 MMm³/day with a cap of 18.08 MMm³/day by the eighth year and would remain at that level until the twentieth year. The term expires on the 31st of December 2019 and may be extended for one more year (ANP, 2019).
- Transportation Capacity Option (TCO) – the objective is to increase the transport capacity by up to 6 MMm³/day of gas over the contractual quantities upon advance purchase. The TCO negotiation also involved Eletrobras and BNDES, and it was agreed that this additional volume would be supplied to thermal powerplants in Mato Grosso do Sul (2 MMm³/day) and São Paulo (4 MMm³/day) (Passos, 2003). The contract is effective until 2041.
- Transportation Capacity Extra (TCX) – it was signed in order to have capacity over the TCQ and TCO contract volumes. Initially, this project was not foreseen. However, with the growing need for natural gas, Petrobras sealed another 6 MMm³/day contract until 2021.
- Transportation contract resulting from the Public Capacity Allocation Competition (CPAC in Portuguese, in 2007) – it is an additional capacity contracted at 5.2 MMm³/day on the southern section, between Paulínia and Araucária, with effectiveness until 2030.

The first public call for capacity access is due to the end of the year, referring to the TCQ, which is equivalent to 60% of the total pipeline capacity (18.08 MMm³/day). However, in line with the CNPE¹² Resolution 16, of Novo Mercado de Gás, Petrobras signed in July this year a Cessation Agreement Term (TCC in Portuguese) with Cade¹³, allowing TBG's control of the sale, until 2021¹⁴. According to the ANP, the public call will be the first step in the process of implementing the capacity reservation regime in Brazil (by entries and exits), allowing several new carriers to reserve capacity and use the transport services in a flexible form and with transparency.

It is noteworthy that Bolivia has natural gas reserves of 0.3 tcm (Table 1), however because of a lack of investments, the production has been decreasing in recent years.

Brazilian Pre-salt

According to Table 1, the Brazilian pre-salt has potential reserves of 0.306 tcm, and a projected 2020 production of 110 million m³/day of natural gas, much higher than the 2018 Brazilian demand, which was of 77.85 million of m³ of natural gas per day¹⁵.

In the country, 31% of all the natural gas produced is reinjected (increasing the reservoir pressure and enhancing its recovery factor) and 3% is burned or lost¹⁶. However, in offshore production fields, this gas is reinjected or burned not only because of strategic measures but also due to the lack of sufficient infrastructure for outflow. Thus, this gas could be used in other ways.

This year, the ANP, EPE and MME launched an initiative called *Novo Mercado de Gás*, which projects the market could triple the country's natural gas market by 2030, attracting investments of up to R\$ 50 billion¹⁷. Among these measures, is the reduction of Petrobras' participation in the natural gas transport and distribution sector, opening doors for other investors, enabling increases in the Brazilian gas market as a whole. In addition, two more LNG regasification terminals are already under construction and the completion of the Rota 3 (Route 3), will drain 18 MMm³/day of natural gas from the pre-salt, thereby increasing gas supply to the country.

Other solutions are also being considered for the use of the gas from the pre-salt beyond the flow to the coast via pipeline. This gas can also be transformed into offshore electric energy, in the Gas-to-Wire model, by building thermal power units adjacent to the production units, and then to flow the energy produced to the coast. A third possibility, is to build a liquefaction station and deliver the liquid natural gas to the coast, via an FLNG (Floating Liquefied Natural Gas).

In addition, it is noteworthy that to the domestic market, the agreement between Cade and Petrobras to end the company's monopoly in the sector was an important step toward a more competitive market. There are still many obstacles to overcome in order to make the pre-salt viable at competitive prices. The largest will be the transportation infrastructure, which is expected to consume billions of dollars in investments and a few years in construction and regulatory adjustments.

As we see in Table 2, natural gas production costs vary between plays. The breakeven price of the pre-salt natural gas can vary substantially, due to transportation costs (because of the distance between the production sites and the coast), due to the CO₂ content, among other factors. The resultant price commonly ranging from US\$6.60 and 8.50 per MMBtu¹⁸, however, it could range from US\$1.8 to 30 / MMBtu.

Table 2: Comparison between natural gas costs in the plays – Vaca Muerta, Bolivia and Pre-salt

	Vaca Muerta's shale gas	Bolivia's gas	Offshore Pre-Salt's gas
Production Costs (US\$/MMBtu)	7	6,7	6,50 - 8,50

Source: Prepared by the authors using data from the ANP, FGV, Mme and PWC, 2019.

Due to recent investments in the Vaca Muerta shale, production costs per well have halved. Thus, the Argentine breakeven in Vaca Muerta is lower than the Brazilian pre-salt. The Argentine wells are also shallower than the Brazilian, which contributes to lower production costs. The price for natural gas from the Vaca Muerta to the Argentine market is US\$ 7 /MMBtu¹⁹. That said, it seems that Argentines do not see the pre-salt's natural gas as an opponent and believe that they can supply a potential Brazilian market with the Vaca Muerta's production, similarly to what Brazil has in contract with from Bolivia with imports through the Gasbol, where the price for the Bolivian gas to its local market is US\$ 6.7 / MMBtu²⁰, without tax.

Final Remarks

Apparently, the necessary investments for the development of the Argentine shale gas in Vaca Muerta play are large, and YPF alone cannot handle it without the IOCs participation, both in the production and construction of a pipeline to outflow the gas. In Argentine's favour is the cohesion of its energy policy and the unison in which businessmen, government and unions work for the

development of the sector. Among the assumptions on which the government is based are that Brazil will not resume the full contract with Bolivia upon its renewal and will not be able to develop the potential of the pre-salt to the point of supplying the growth of the local market.

The decision that is in the hands of the Brazilian government is more than a matter of energy security. This is a strategic decision on the need for pre-salt gas development since the nearest alternatives for supply are not substantially viable either due to depletion of reserves or due to absence of external investments.

Thus, the *Novo Mercado de Gás* programme comes at a good time, signalling the strong interest of the Brazilian Federal Government in enabling a natural gas policy and also guiding the action of state government to privatize gas distributors and ensure the proper functioning of major consumers, among other aspects that are essential to market opening.

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Endnotes

¹Petrobras controls the entire domestic natural gas offer. The production in April was of 113 MMm³/day, in which Petrobras produced 87 MMm³/day and other companies produced 25.9 MMm³/day. Only 50.3 MMm³/day of this production was supplied to the market, as 38.6 MMm³/day was reinjected. The independent producers sell their available gas to Petrobras, usually at the wellhead.

²Vaca Muerta: Argentina’s energy future, PWC, May 2018.

³Ineep – Instituto de Estudos Estratégicos de Petróleo, Gás Natural e Biocombustíveis Zé Eduardo Dutra.

⁴<https://www.abegas.org.br/arquivos/72452>

⁵<https://petronoticias.com.br/archives/126964>

⁶Yacimientos Petrolíferos Fiscales.

⁷<https://oilprice.com/Latest-Energy-News/World-News/Argentina-Exports-First-Ever-Cargo-Of-LNG.html>

⁸Vaca Muerta: Argentina’s energy future, PWC, May 2018.

⁹<https://www.abegas.org.br/arquivos/72452>

¹⁰https://www.clarin.com/clarin-em-portugues/destaque/petrobras-sugere-missao-comercial-da-argentina-empresendimentos-gas-brasil_0_BR_6RWF10.html

¹¹Moraes, F., Brasil, Bolívia e Argentina: Gás Natural, Mercado e Acessos. Boletim de Conjuntura Abril/2019, coluna opinião, FGV Energia. 2019. <available at: https://fgvenergia.fgv.br/sites/fgvenergia.fgv.br/files/boletim_abril-2019.pdf>. Accessed at 10th of July 2019.

¹²Conselho Nacional de Pesquisa Energética.

¹³Conselho Administrativo de Defesa Econômica.

¹⁴The sale of TBG shares will only occur after the contracting of the due capacity.

¹⁵Boletim Mensal de Acompanhamento do Gás Natural, MME, July 2019.

¹⁶Boletim Mensal de Acompanhamento do Gás Natural, MME, July 2019.

¹⁷<http://www.mme.gov.br/web/guest/principal>

¹⁸<http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/informe-custos-de-gas-natural-no-pre-sal-brasileiro>

¹⁹Vaca Muerta: Argentina's energy future, PWC, May 2018.

²⁰<http://www.gasenergyla.com/with-which-reserves-and-gas-production-capacity-will-bolivia-negotiate-with-brazil/>

The New Geopolitics of Natural Gas in Eurasia: Where India Will Fall?

Said N. Azam

In her book, the New Geopolitics of Natural Gas, Agnia Grigas states that American supremacy in oil and gas, propelled by the boom in shale production in the United States, will disturb the balance of power in Eurasia. Grigas's thesis states that Russia, as the main provider of gas in Europe, will lose some of their economic and political power; the foreign policy tools that Russia has traditionally exercised over European countries for decades to advance Russia's geopolitical goals. Consequently, Grigas concludes, that Russia will become more dependent on China for exporting their natural gas. It will then be an avenue for China to manipulate Russia's dependency itself to advance China's own geopolitical goals in Eurasia and beyond (Grigas, 2017). This paper highlights that India will benefit from the Shale gas boom in the United States, whereas, it will suffer as a result of Russia's dependence on China.

In the scenario where Russia will become more dependent on exporting gas to China, the geopolitical implications would be far greater than only weakening Russia's position. It will also give an upper hand to China vis-à-vis India. India is already in a comparative disadvantage position for lacking connectivity to any gas- and oil-producing country via pipelines.

China has the luxury of being connected to oil and gas reserves in Central Asia and Russia via pipeline networks. China for the first time ever imported natural gas through a pipeline just ten years ago. After a successful launch of the first line of the Central Asian Gas Pipeline (CAGP) that connected China to Turkmenistan, the two partners agreed to add three additional pipelines: Line B, Line C, and Line D. (Grigas, 2017). Also, China is expected to receive gas via the Power of Siberia pipeline from Russia at the end of 2019 (Papageorgiou, 2019).

The Power of Siberia is part of the \$400 billion deal, signed in 2014, according to which Russia will provide over one trillion cubic meters of gas to China over thirty years. More importantly, China possesses within its territory the largest shale gas reserves in the world and a substantial quantity of oil reserves. It is also the world's largest producer and consumer of coal. Moreover, China imports substantial quantities of oil and gas via the sea from multiple foreign sources, including Russia and the United States. Aggregately, the out of necessity, Russia's tilt toward and dependence on China, will further increase the latter's ability to have access to energy products in abundance and at a lower cost, which means the attainment of energy security (Grigas, 2017).

In contrast, energy-poor India is greatly reliant on imports of energy products through marine vessels. A fact that makes the country very vulnerable from a national energy security perspective (Grigas, 2017). India is projected to be the most populous country in the world by

2040. It is already the third-largest economy, after the United States and China. India is the fourth largest consumer of energy products after the United States, China, and Russia. However, it has one of the lowest per capita energy consumption rates in comparison to other large economies such as China and South Korea (IAE, 2018). In an event of a natural- or human-made disruption in international waters, the Indian economy and society will suffer.

India feels that it has been systematically pushed to the periphery by its primary rival and competitor, China. China's ambitious Belt and Road Initiative (BRI) initiative has placed India in an uncomfortable situation. India views China's BRI as a factor potentially making India further isolated from its neighbourhood in the region. Therefore, from India's perspective, the BRI is counterproductive for India's ability to attain "prosperity for its citizens" (Khurana, 2019). The main objectives of BRI are to connect China via landlocked Central Asia to Europe. The second portion of the BRI, 21st Century Maritime Silk Road, will connect Southeast Asian growing economies to China via seaports and railways (Cai, 2017).

India has tried in the past, though unfruitful so far, to connect to energy-rich Central Asia via pipeline(s). India, along with its neighbour Pakistan, are members in the pipeline project known as TAPI. Since the mid-1990s, initially, Turkmenistan, Afghanistan, and Pakistan and later India joined the initiative to extend a gas pipeline from gas-rich Turkmenistan to energy-deficient Pakistan and India. Acronym TAPI represents, respectively, the first letter from Turkmenistan, Afghanistan, Pakistan, and India. Primarily the security situation in Afghanistan and Baluchistan in Pakistan has stopped the project from becoming operational since its formation (Grigas, 2017). Another hindering factor could be the lack of experience among member states in managing transnational pipeline projects, particularly those involving security challenges.

Also, India has explored a potential gas pipeline connecting Russian Siberia to India either through China or Iran (Times, 2016). India is also looking to the construction of a sub-sea gas pipeline, with the help of Russia that will connect Iran to India via the Oman Sea and the Indian Ocean (Roy, 2019). The prospect for the implementation of these projects seems low due to technical constraints, higher cost, and geopolitical consideration (Times, 2016).

India was one of the first countries that received American LNG tankers. Indeed, the entrance of the US as a liquefied natural gas (LNG) exporter in global gas markets is an auspicious development, though minor, towards achieving India's energy security. Because, in addition to Qatar, Australia, Russia and other LNG exporting countries, US LNG can provide an extra lifeline for the gigantic economy of India (Grigas, 2017). It is also noticeable that US LNG export to Europe increased over 270 percent since 2016 when US started exporting LNG (EC, 2019).

Leaders of the energy sector in Russia must have been examining challenges and opportunities ahead for their industry in the wake of the American shale boom. China's successful initiatives for diversifying its energy sources is an additional factor for making them worried about the future of Russia's energy products. Russia's economy and also its status as a major global power, are substantially dependent on revenues generated by exports of oil and gas. Europe and China are the biggest, respectively, markets for Russian gas (Grigas, 2017). Whatever conclusion they make, pragmatically, they do not want to see Russia's lucrative source of revenues between a rock and a hard place. India needs to capture and invest in this momentum.

India can propose a gas pipeline project to Russia that connects the two countries. In addition, probably an oil pipeline too. One option is that India teams up with other TAPI members to invite Russia to join their collective effort. Alternatively, India, together with Russia, can design a new gas pipeline that either extends parallel to the proposed TAPI route after it reaches from Russia to Turkmenistan; meaning; Russia, Kazakhstan, and then Turkmenistan, Afghanistan (Kandahar), Pakistan (Baluchistan) and India; or through a different route that starts from Russia and continues via Kazakhstan, Uzbekistan, Afghanistan (Jalalabad), Pakistan (Khyber Pakhtunkhwa), before it reaches India. Even better from India's energy security point of view, if Russia joins the TAPI and participates in building an additional energy corridor.

India's initiative to invite Russia to join TAPI will be identical to China's decision in 2006 which captured the momentum presented as a result of the difficult relationship between Turkmenistan and Russia over gas prices. Back then, Russia would buy gas from landlocked Turkmenistan at a lower price and resell it to its customers in Europe at more than double the price (Grigas, 2017). When the president of Turkmenistan visited China in 2006, China immediately embraced the opportunity and invested. As a result of that pragmatic vision and decision, today, China is in a uniquely comfortable status in terms of its energy security.

Inclusion of Russia in the TAPI or in an alternative pipeline project will make building an energy corridor from Eurasia to the Indian subcontinent more feasible. Russia has decades-long experience in managing transnational pipeline projects. It also possesses resources as a regional power which could be effective in withstanding potential security challenges ahead of the pipeline(s). Recent political developments in Afghanistan in which Russia has been playing a prominent role could improve the feasibility of gas and oil pipeline project(s) via Afghanistan.

Moscow has hosted several rounds of peace talks between the Taliban, the main militant group in Afghanistan, and other political factions (Marson, 2018) and (Roy, 2019). US government officials also have been negotiating with the Taliban for a peace deal (Qazi, 2019). US officials and representatives of the Taliban, in peace talks, have expressed their optimism for reaching a political settlement. The Taliban movement is the largest group that has actively strived to disrupt security in Afghanistan in the last two decades. Those parts of Afghanistan that the TAPI will pass through, have frequently witnessed violent scenes since 2001. Many observers believe that Russia's relationship has improved substantially with Pakistan in recent years (Butt, 2019). Russia has a history of a good relationship with India.

Historically Russia has tried to bar Central Asian republics from exporting their energy products directly to markets in Europe. "Russia was reluctant to allow Turkmenistan to pursue its proposed 300km gas pipeline to Azerbaijan, which would open up its huge, cheap, gas reserves to a European market at present dominated by Gazprom," (Greenwood, 2018). Russia will become dependent on Central Asian countries when it exports its gas and oil via pipelines to South Asia. Russia will inevitably choose to cooperate rather than to dominate its less powerful neighbours in Central Asia. Consequently, Turkmenistan and other energy-rich countries in the region might be set free to export their products to lucrative markets in Europe and elsewhere.

For Russia, its lucrative industry and its status as a major power are at stake. For India, it translates to a golden and a rarely found opportunity availing itself which the South Asian power can use for attaining its energy security. A goal that India has been striving for decades to achieve. Moreover, the phenomenal development will mark itself as a new dawn in the history of cooperation between regional countries. When Pakistan and India celebrate the 75th anniversary of their independence in 2022, the two nations will have more hopes for a prosperous and peaceful future than to commemorate the tragic events of the past.

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