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NATURAL GAS SUPPLY AND PRODUCTION OF AMMONIA AND UREA IN MEXICO: STRUCTURAL SETBACKS AND POLICY IMPLICATIONS

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DECEMBER 18, 2014

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Abstract

The production activities of several important industrial sectors in Mexico depend on an inadequate supply of natural gas. After decades of underinvestment, the country's natural gas pipeline network faces severe limitations in capacity and geographical coverage, leading to limitations in meeting domestic demand. To correct this, the government has launched an aggressive program to upgrade natural gas transport capabilities. However, Mexico is likely to see stronger consumer demand in the years to come. The country possesses important natural gas reserves that it does not have the capital to exploit. The recent energy reform in Mexico aims to correct this shortcoming by attracting foreign investment in the natural gas sector. The government's recent natural gas-related infrastructure program and energy reform are designed in part to help decrease the country's reliance on imports of fertilizers (urea) and basic food staples, which stand at approximately 70 percent and 43 percent of domestic consumption, respectively. Increasing natural gas production and infrastructure will contribute to gains in ammonia and nitrogen fertilizer production,¹ which would in turn have a positive impact on Mexico's agroindustry. This paper analyzes how structural issues related to natural gas supply contributed to greater dependency on fertilizer imports. Furthermore, it demonstrates that regulatory changes can incentivize policies to increase production of ammonia and urea, which would reduce Mexico's dependency on imports of both nitrogen fertilizers and staple foods, such as corn, wheat, and other grains.

¹ Discussion and figures throughout the text refer to nitrogen fertilizers, which according to the Standard International Trade Classification (SITC) used by the United Nations Commodity Trade Database are classified as follows: urea (310210), ammonium sulphate (310221), ammonium sulphate-nitrate mix (310229), ammonium nitrate (310230), ammonium nitrate limestone (310240), sodium nitrate (310250), calcium-ammonium nitrate mix (310260), calcium cyanamide (310270), urea-ammonium nitrate mix (310280), and nitrogenous fertilizer mixes (310290). Numbers in brackets are SITC codes given to each commodity. In the present analysis, particular attention is paid to urea, because it accounts for a large percentage of imports and domestic consumption.

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Introduction

In December 2013, Mexico's President Enrique Peña Nieto submitted a constitutional amendment to reform the country's energy sector, and Congress promptly approved it. This initiative will open Mexico's energy sector to private and foreign investment and eventually end the monopoly that Petróleos Mexicanos (PEMEX), the national oil and gas company, has held over hydrocarbons for more than seven decades. Though the benefits of this structural reform are numerous, one of its most significant contributions will be overcoming structural shortcomings that prevent productivity gains in a wide range of economic sectors—including the agricultural industry. In fact, a review of the stated objectives of the government's energy reform shows that it will result in a more adequate supply of natural gas, which in turn will lead to increased production of affordable fertilizers and—down the line—increased production of national foodstuffs at lower prices (Presidencia de la República 2014a).

The causal chain that the government proposes (more natural gas will lead to increased production of fertilizers, which will result in greater agricultural production) may prove difficult to examine in advance, given the complexity of this chain of objectives. But Mexico's government believes that increasing the supply of natural gas will have a positive effect on ammonia and urea manufacturing and ultimately on agricultural production—leading to a decreased dependence on agricultural imports. The statistics support the arguments of the Mexican government. It is worth noting that the nitrogen fertilizer industry in Mexico was brought to a near halt in the late 1990s, and the agricultural industry became dependent on fertilizer imports.² Today, approximately 70 percent of domestic consumption of nitrogen fertilizers in Mexico is filled by imports, with urea representing 76.9 percent of all nitrogen fertilizer imports between 1996 and 2013 (UN Comtrade Database 2014).³ This collapse was a key factor behind Mexico's growing dependency on imports of basic food staples, including

² With respect to all nitrogen fertilizers, Mexico's imports in 2013 totaled US\$760 million, of which US\$187 corresponded to China, US\$169 million to Russia, US\$107 million to the United States, and US\$87 to Ukraine. These four countries accounted for 72.5 percent of the country's overall imports. In the case of urea, Mexico's imports in 2013 reached US\$498 million, of which US\$151 corresponded to Russia, US\$140 million to China, and US\$87 million to Ukraine. In that year, these three countries represented 75.9 percent of the country's imports (UN Comtrade Database 2014)

³ Values in US dollars. In metric tons, urea accounted for 76.55 percent of all nitrogen fertilizer imports in that same period (UN Comtrade Database 2014).

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corn, beans, sorghum, rice, and wheat. Official estimates put the figure at 43 percent, demonstrating the inefficiency and structural flaws of Mexico's agricultural sector, which was unable to compete with the American agroindustry after the North American Free Trade Agreement passed in 1994. Reinforcing the Mexican government's argument are the recommendations of the Food and Agricultural Organization of the United Nations (FAO) in regard to food sovereignty. The FAO argues that a country is at risk when it imports more than 25 percent of its food staples (CVASF 2014a).

These statistics are a major motivator behind the government's actions. For government officials, reversing Mexico's agricultural imports dependency means strengthening the fertilizer industry, which in turn requires correcting natural gas domestic supply conditions.

Mexico's national infrastructure program and the energy reform of 2014 must be understood partly as correcting what the government sees as a major problem of food dependency. Policymakers intend to ameliorate these unfavorable structural conditions by expanding the national system of natural gas pipelines, upgrading ammonia facilities at PEMEX's petrochemical complex in Cosoleacaque—the country's only natural-gas-to-ammonia plant in operation—and rehabilitating a nitrogen fertilizer plant in nearby Coatzacoalcos, which has been idle since the late 1990s.⁴ Recent developments indicate that PEMEX has indeed taken solid steps toward reactivating the natural gas supply and linking it to ammonia and urea production (see Figure 4).

The current state of Mexico's agriculture, at least with respect to basic food staples, is rooted in several factors, including trade liberalization, limited access to credit for Mexican farmers, and agricultural subsidies in the United States. These factors led to increased agricultural imports from the United States and fed into Mexico's inability to meet a greater proportion of domestic demand for basic food staples. Otero (2011) and Wise (2009) describe these factors in their work. In this paper, we turn our attention to Mexico's inability to produce affordable nitrogen fertilizers and what the government is doing to address this issue. We argue that strengthening

⁴ Both the petrochemical complex of Cosoleacaque and the nitrogen fertilizer company are located in the state of Veracruz in southwest Mexico.

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the country's ability to produce ammonia-urea is part of a national policy of managing and even decreasing food import dependency. At a broader level, this logic responds to the government's urge to demonstrate that constitutional changes in the hydrocarbon sector will also deliver benefits in the agricultural sector sooner than anticipated.

This policy paper has two goals. The first is to analyze how deficiencies in the natural gas supply network contributed to greater dependency on imports of fertilizers. The second is to demonstrate that regulatory changes in the energy sector can incentivize policies aimed at increasing the production of ammonia and urea and, by extension, help strengthen the country's food sovereignty.⁵

Issues in the Natural Gas Supply

From 2009 to 2013, the volume of natural gas produced in Mexico fell by 9.4 percent (SENER 2014). Declining production and the lack of adequate transportation infrastructure has constrained Mexico's ability to meet domestic demand for natural gas, as illustrated in Figure 1. Many natural gas consumers throughout the country, including the petrochemical complex of Cosoleacaque and other nitrogen fertilizer producers, have had difficulties in securing supply for their economic activities. In this context, the Mexican government aims to address this problem primarily through two actions.

The first has to do with the energy reform of 2014. Regarding natural gas supply, the reform anticipates boosting production by attracting private and foreign investment to develop the country's significant conventional and unconventional gas reserves, which stand at 17 and 545 trillion cubic feet, respectively (PEMEX 2013a; EIA 2013). This would be a relatively convenient solution, given Mexico's potential to become a major gas producer. However, the extent to which the new institutional and regulatory framework will appeal to private and foreign investors remains to be seen.

⁵ In this paper, "food sovereignty" refers to the extent to which Mexico's food production is self-reliant, rather than relying on imports of basic staple foods (corn, rice, beans, sorghum, and wheat) to meet domestic demand.

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The second major action refers to building the infrastructure and opening the market to import greater quantities of natural gas from the United States, where output has grown considerably—22.3 percent between 2007 and 2013 (EIA 2014b; EIA 2009)—due to innovative techniques to extract shale gas. As a result, North American firms and consumers have access to low-priced natural gas, with 2014 prices⁶ averaging US\$4.51 per million Btu,⁷ down from US\$8.86 in 2008 (EIA 2014a). This solution, however, would simply transfer Mexico's dependence from fertilizer and agricultural imports to natural gas imports, keeping the country in a condition of sovereign vulnerability.

Whichever of these two potential solutions Mexico implements, neither will work without upgrading the country's existing pipeline network. Natural gas supply is unsatisfactory not only because of insufficient domestic production or even barriers to imports, which are relatively low, but also because of inadequate transportation infrastructure. The national pipeline system is limited in both capacity and geographical reach, as it fails to deliver natural gas to key industrial regions and operates above optimal levels.⁸ Modernizing the gas pipeline network is key to either of the two solutions outlined above. Transporting natural gas by truck or railway is simply unfeasible, given Mexico's deficient road and rail infrastructure as well as the costs of doing so. Thus, without a modern natural gas pipeline network, Mexico cannot realize the goal of ultimately decreasing its dependence on imported nitrogen fertilizers. In order to eliminate these deficiencies, the government has already invested in considerable upgrades to the national system of natural gas pipelines (Presidencia de la República 2014c), and more is yet to come, according to national infrastructure plans. This makes sense, given that the government's success in energy reform depends in part on an increased supply of cheaper natural gas. But this will take time as well as a well-implemented, mid-range plan. It is clear that if natural gas transport capabilities remain unchanged, the potential benefits derived from recently enacted regulations will be extremely difficult to achieve.

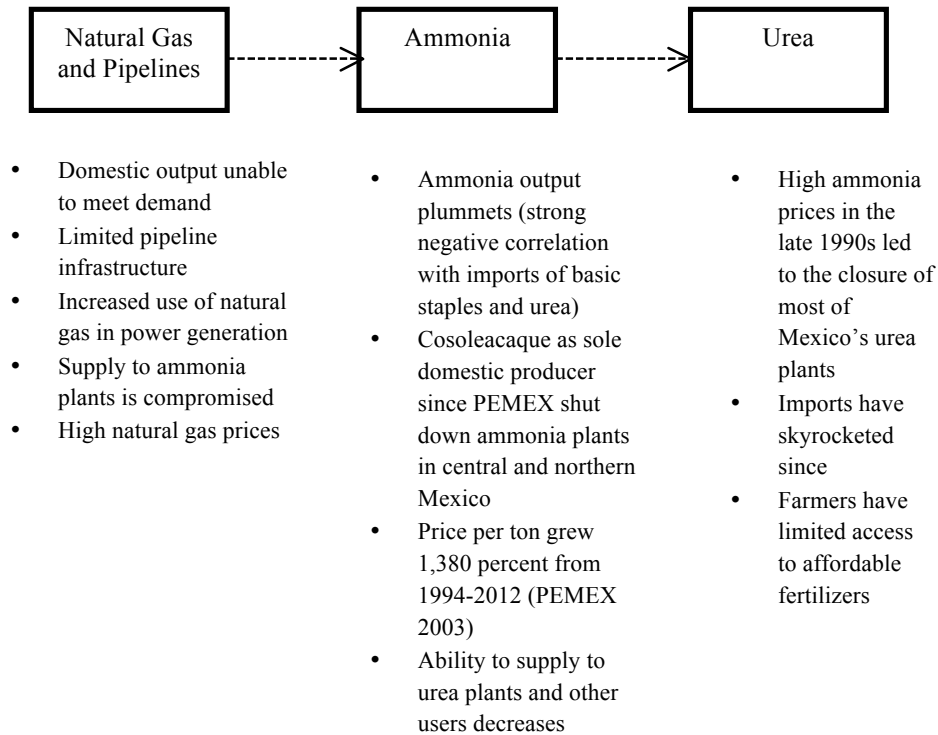
⁶ 2014 prices measures from January to October. Value in dollars per million Btu refers to the Henry Hub Natural Gas spot price.

⁷ British thermal unit.

⁸ The notion of optimal usage, which is reckoned to be around 85 percent, basically refers to a utilization level where the pipeline network is able to absorb demand variations from different users. In 2012 pipelines worked at 93 percent of the network's handling capacity (Presidencia de la República 2014c).

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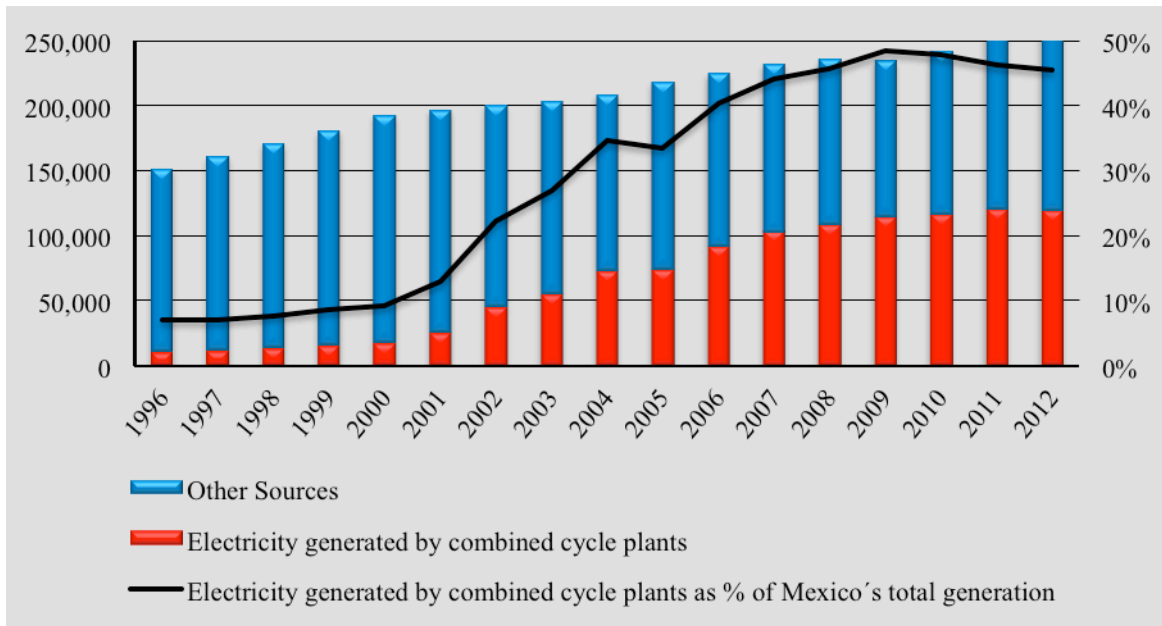
Figure 1. Determinants of the Disarticulation of the Urea Chain in Mexico



Review of the Post-NAFTA Context

Since the 1990s, Mexico has implemented policies to meet higher levels of electricity consumption. The country's strategy has relied on the growing use of combined cycle plants, which are intensive in natural gas usage. But the strategy has worked, to some extent. From 1996 to 2012, power generation grew 72.42 percent, primarily due to the extra output of combined cycle plants. The output of these plants has in fact increased from 10,661 to 119,300 GWh during that same period. To put these figures in context, only 7 percent of the total energy generation came from these plants in 1996, but their electricity output continued to grow at modest yet consistent rates in the years after 1996. From 2002 onwards, the share of combined cycle plants in overall power generation skyrocketed, with an average growth per year of 10.3 percent, far outpacing the 2.7 percent electricity generation rate experienced by the overall production of energy. By 2012, official estimates highlighted that 45.55 percent of Mexico's power generation came from combined cycle plants, as shown in Figure 2 (SENER 2007a, 2013a).

Figure 2. Mexico's Electricity Generation Outlook in GWh, 1996–2012



Source: SENER (2007a, 2013a)

From 1994 to 2000, President Ernesto Zedillo's administration anticipated that a larger number of combined cycle plants would eventually require greater transport capacity for natural gas. In light of this, only a year after NAFTA entered into effect, the Zedillo administration embarked on a process of deregulating the natural gas market. By 1995, the petroleum law was amended in order to allow the participation of private capital in the transportation, storage, and distribution of natural gas and in the construction and operation of pipelines (Lajous 2013; Torres-Barón 2009). Even so, investment failed to significantly increase the existing pipeline network, which consisted of a mere 9,185 km by 1998 (PEMEX 1999). From further opening of the pipeline infrastructure sector to 2012, private investors have added 2,098 km of pipelines, with the great majority—about 1,661 km—constructed between 1997 and 2003 (SENER 2013b). With little investment after 2003, coupled with a natural gas demand growing at 4.2 percent each year from 2002 to 2012, it comes as no surprise that supply failed to meet surging demand in 2013.

As for nonrenewable sources—diesel, fuel oil, and coal—the share of natural gas in electricity generation was second to that of fuel oil, accounting for 17.5 and 65.74 percent, respectively, in 1996. But with more combined cycle plants becoming operational at the beginning of the 2000s,

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natural gas usage gained pace until it turned into the most important source (see Figure 3). In 2006, government officials estimated that 50 percent of the electricity produced by the public sector was generated from natural gas—a figure that kept growing until it reached 56.7 percent in 2012, meaning that the annual average growth of natural gas penetration expanded 7 percent per year, on average, from 2002 to 2012. By then, fuel oil only accounted for 25.6 percent (SENER 2007b, 2013b).

There is no doubt that this increase in consumption of natural gas for electricity production illustrates a fundamental shift in the configuration of the country's energy production matrix. However, it is important to emphasize that Mexico's natural gas pipeline infrastructure did not expand at all during this period. In its 2003 and 2013 annual reports, PEMEX states that the length of its gas pipeline network stood at 9,511 km in 2002 and 9,038 km a decade later.⁹ This represents an actual decrease in PEMEX's pipeline assets. If privately owned and operated pipelines are taken into account, the national network of pipelines rises to 11,142 km. Rising demand in Mexico puts further pressure on its inadequate pipeline infrastructure. Demand from the manufacturing sector was higher than expected in 2012, as gross domestic product grew 3.8 percent, putting further pressure on national natural gas supplies and exposing the insufficiency of the distribution network (SENER 2013b).

It is clear that natural gas transport infrastructure failed to keep up with surging domestic demand, leading to supply bottlenecks, some of which became so acute that PEMEX had to ask consumers to reduce natural gas consumption in 2012 and 2013 (Coldwell 2013). In these cases, PEMEX issued critical alerts, which are defined as “situations in which consumers are requested to slow down consumption of natural gas in a given volume in order to keep the national system of pipelines fully operational until the problem that caused the alert is solved” (SENER 2013c). PEMEX¹⁰ reportedly issued 22 critical alerts¹¹ throughout the year, forcing manufacturers in many of the country's industrial regions to undergo vast periods of lost productivity (IMCO 2013). Clearly, flaws in the supply network left natural gas consumers to vie for supplies in an environment characterized by rising demand—which grew at an annualized rate of 4.2 percent

⁹ As reported by PEMEX Gas & Basic Petrochemicals.

¹⁰ From December 2012 to July 2013, PEMEX issued 15 critical alerts (Coldwell 2013).

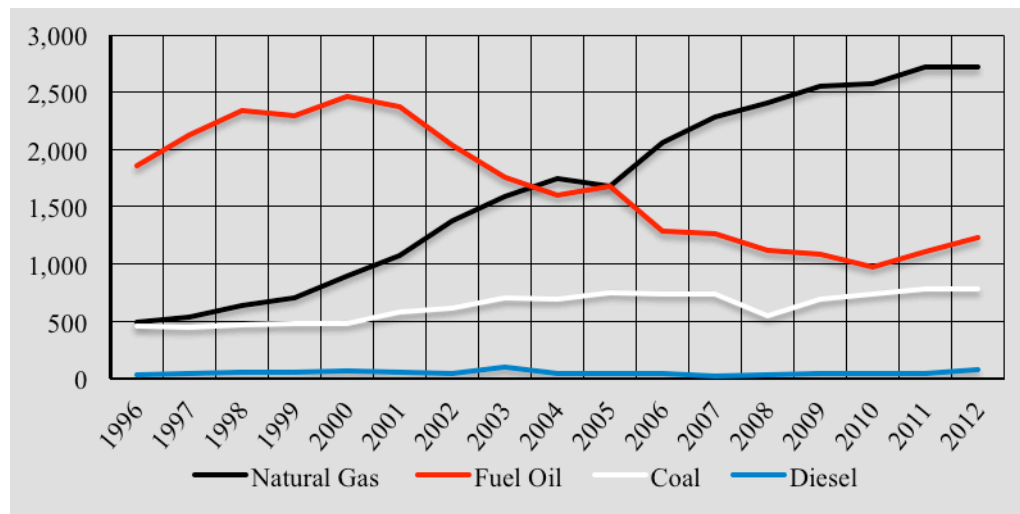
¹¹ However, media outlets reported that PEMEX issued more than 100 critical alerts in 2012 (Johnson 2013).

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from 2002 to 2012 (SENER 2013b), coupled with falling production and a pipeline network functioning at near full capacity (IMCO 2013) but insufficient to supply all consumers throughout the country.

Figure 3. Demand for Nonrenewable Sources of Power Generation, 1996–2012

Million cubic feet of natural gas equivalent per day



Source: SENER (2007b, 2013b)

The largest consumers of natural gas in Mexico are, by far, the electricity sector and PEMEX, which consume 46.6 and 30 percent of overall supply, respectively. Industrial consumers habitually stand at the end of the supply line—their gas requirements accounted for 17.7 percent of total supply in 2012 (SENER 2013b). For decades, construction of pipelines responded to the needs of the energy sector, leaving industrial consumers out of the equation.

All things considered, policymakers understand how strategically important it is to grow the natural gas pipeline network. This is evident in the laws of the 2014 energy reform, which call for boosting productivity across diverse economic sectors, including ammonia and fertilizers. And this, along with the expected increase in both production and demand of natural gas in the years to come, is what makes upgrading the pipeline network urgent.

Overcoming Structural Shortcomings: Mapping out Pipeline Investments

Upon announcing changes to the energy sector in August 2013, Mexico's government launched a public relations campaign to gain public support for the reform. One of the main arguments of this campaign is that opening the energy sector to private and foreign investment would eventually lead to an increase in the natural gas supply and a consequent decrease in its price. In turn, an abundant and cheaper supply of natural gas would lead to an increase in power generation, with benefits extending throughout the economy, including the manufacturing sector. For the purposes of our paper, the increase in supply and decrease in prices would also improve the availability of natural gas for the fertilizer industry, which would provide a boost to the agricultural sector. This promised chain reaction sparked by energy reform begs the question: How can policymakers secure the success of the energy reform and thereby ensure greater access to affordable natural gas for both household and industrial consumers?

The answer might require an analysis of the potential increase in the natural gas supply through private and foreign investment participation in gas exploration and extraction. This analysis requires some assumptions given that, even though the constitutional changes have already been approved and the enabling legislation has already passed, the regulatory framework is still evolving, and many of these rules have yet to be implemented. In the meantime, the short-term solution to increase the supply of natural gas appears to be a significant investment in pipeline infrastructure designed to import natural gas from the United States.

According to the 2014–2018 National Infrastructure Program, the Mexican government is in fact pushing for an expansion of the pipeline network, not only anticipating the reform but also considering the fact that the output of shale gas in the United States has skyrocketed, and it may be less expensive to simply import it in the short term. The 2014–2018 National Infrastructure Program projects investments¹² of MX\$227.2 billion to upgrade gas transport and storage facilities—a figure nine times larger than what the previous administration invested in the period of 2007 to 2012 (Presidencia de la República 2014c). All this suggests that the investment in infrastructure is primarily designed to import natural gas for a quick increase in natural gas

¹² This includes private participation.

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supply and a decrease in prices, and eventually to bring private and foreign investment in line to reduce dependence on imports—a longer-term goal.

Mexico's government is clearly attempting to match natural gas supply and prospective natural gas demand—which shows no signs of slowing down—with a complex strategy of imports and eventual expansion of national production. Given this complex scenario, Mexico has no option but to delineate a strategy to upgrade its capabilities to handle larger quantities of natural gas. Mexico's secretary of energy estimates that by 2027, 57.6 percent of overall demand will come from power generation, driven mostly by combined cycle plants. These plants are projected to represent 66.63 percent of the additional capacity installed by that same year. This is equivalent to an expansion of 5.1 percent per year in the estimated natural gas demand from the electricity sector alone. That is well above the country's gross domestic product growth, estimated to grow 3.7 percent per year from 2012 to 2027 (SENER 2013a; SENER 2013b).

On the supply side, the shortage is even more dramatic. Natural gas production will not be able to keep up with consumption. Production is estimated to increase by 1.3 percent per year, while consumption will increase at a rate of 3.6 percent per year, further widening the gap between demand and supply over time. Thus, imports will have to expand much faster, at a yearly rate of 7 percent, and will eventually account for 51.3 percent of overall national supply by 2027—up from 31.6 percent of the national supply in 2012. This surge reveals that natural gas supply from the United States will play a much greater role in Mexico's energy matrix (SENER 2013a; SENER 2013b).

Even though these figures were calculated in 2013 before the approval of energy reform in 2014, they still illustrate how Mexico is becoming more dependent on natural gas imports in the midterm. There is reason to believe that energy reform will not change these calculations. Both the shale gas boom in the United States and the resulting fall in prices have provided Mexico with a convenient source of supply.

Furthermore, although Mexico has identified the need to upgrade the pipeline network, that infrastructure will take years to put together. In the meantime, rising domestic demand for

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natural gas will have to be met with imports. Worse yet, if demand from Mexico's manufacturing and power sector continues to grow, this will increase the pressure on ensuring an abundant supply of natural gas at lower prices. The natural source is the inexpensive natural gas coming from north of the border. These arguments appear to be in line with Mexico's Natural Gas Supply Strategy (*Estrategia de Suministro de Gas Natural*). To further corroborate this scenario, the pipeline network under construction is largely designed to transport natural gas from the United States to Mexico (PEMEX 2013b). The rhetoric matches the structural design of the natural gas pipeline infrastructure network. PEMEX CEO Emilio Lozoya, CEO of PEMEX, has also remarked that "projects of this kind [pipelines] guarantee that Mexico will join the energy revolution in North America," signaling that the thriving shale gas industry in states such as Texas is shaping policy in Mexico (PEMEX 2014c).

Thus, Mexico understands its shortcomings in regard to natural gas supply, and it has chosen to meet demand with two principal strategies. The first is to increase domestic output of natural gas through energy reform and regulatory changes—although this strategy will take longer. The second is to increase natural gas supply through imports from the United States. More pipelines are crucial for both routes to be plausible. This explains why Mexico has decided to invest heavily in upgrading and expanding its pipeline network. In fact, in reviewing the 2014–2018 National Infrastructure Plan, SENER's 2013–2027 Prospectus on Natural Gas (*Prospectiva de Gas Natural and Gas L.P* in Spanish), and the Strategy for Natural Gas Supply, it is evident that the range of the pipeline network that Mexico aims to build follows these objectives. As shown in Figure 4, border connectivity is set to undergo a substantial upgrade, with Tamaulipas, Nuevo León, Chihuahua, and Sonora being major entry points for US natural gas.

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Figure 4. Mexico's Prospective Pipeline Infrastructure



Source: Baker Institute, using data from Mexico's Office of the Presidency and Energy Ministry

Considering this major pipeline strategy, it is worth stressing that the Los Ramones pipeline project, estimated to cost US\$2.5 billion and reach a length of over 1,000 km, has been touted as the most important project of its kind in the last four decades. It is anticipated to become operational in 2015 and increase supply by 20 percent. Figure 4 shows that Los Ramones will be connected to Agua Dulce, Texas (number 15 on the map). From Agua Dulce, natural gas will be transported through the states of Tamaulipas, Nuevo León, San Luis Potosí, Querétaro, and Guanajuato (numbers 17, 18, and 22), supplying many of the firms that saw urgent shortages in recent years (PGPB, n.d.; PEMEX 2014c). One of the benefits of the Los Ramones network is that supply bottlenecks in northeast Mexico will be eased due to the added transport capacity, and this in turn will allow transportation of more natural gas to states like Veracruz, home to

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PEMEX's ammonia and urea plants. PEMEX (2014b) estimates that this development will boost ammonia and urea production. This in turn fits the overall idea that an added objective down the line is to strengthen Mexico's fertilizer supply and ultimately its agricultural industry.

All things considered, the rationale behind expanding the country's pipelines network is basically associated with the potential implications of having access to low-priced natural gas, first from the United States and then from national supplies. Of these potential implications, the supply of natural gas to combined cycle plants is greatly significant. Power generation in several states is projected to shift to a more intensive use of natural gas, which may increase productivity for energy-intensive industries through access to competitively priced electricity. What is more, greater availability of the input in certain regions is thought to diversify productive activities. For example, the Gasoducto del Noroeste—which is made up of six segments (numbers 2, 9, 10, 12, 13, and 14 in Figure 4) that run from Tucson, Arizona, to Mazatlán, Sinaloa, and from El Encino, Chihuahua, to Topolobampo, Sinaloa—may attract investments from a wide range of industries, including fertilizer manufacturers (Gobierno de Sinaloa 2014). This is further reinforced by the fact that Sinaloa is Mexico's breadbasket, and its agricultural sector is key to the national food supply. Thus, pipelines running north to south are central in Mexico's efforts to ultimately ease its dependence on imports of urea and, by extension, strengthen food sovereignty.

Dependence on Imports of Urea and Basic Food Staples¹³

Ammonia production plays a central role in understanding the decline of the nitrogen fertilizer industry in Mexico. Its production has decreased sharply in the past two decades. In 1996, the petrochemical complex of Cosoleacaque managed to yield 2.5 million metric tons of ammonia. At that point, natural gas supply was still abundant and relatively inexpensive. But as the prices of natural gas being supplied to industrial consumers rose, ammonia output plummeted to 923,000 metric tons by 2000—representing 37 percent of the ammonia production level four years earlier (PEMEX 2002; PEMEX 2013a).

¹³ In this complex equation, we ought to analyze statistics of urea production. However, available sources disclose figures in a rather inconsistent manner, which in the end would problematize the construction of valid arguments. That is why analysis of ammonia production receives more attention.

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What lies behind this sharp decline in ammonia production is the introduction of price control policies that hitched the price of natural gas in Mexico to the price of natural gas in the southern coast of the United States, which during that period was among the world's highest prices. This 1996 decision was related to Mexico's commitments under the North American Free Trade Agreement (NAFTA) and the perceived need that Mexico needed to bring its regulatory framework, including prices, in line with that of the United States and Canada. There was much enthusiasm for standardization of regulations at that time, something that was often interpreted as reducing price differentials. Along those lines, policymakers increased the domestic price of natural gas to match the price in Texas, believing that a lower price could be seen by US firms as unfair competition (Duhalt 2011).

Consequently, PEMEX adjusted the price of ammonia upwards, from MX\$854 in 1995 to MX\$1,816 in 2000—a jump of 212 percent in a span of five years (PEMEX 2002). This surge in the price of ammonia severely affected urea producers and made it increasingly difficult for Mexican farmers to access affordable fertilizers. Mexican policymakers resolved to remove import duties for urea so that Mexican farmers could buy fertilizers at more competitive prices. Nonetheless, the policy backfired when it contributed to the shutdown of most urea facilities in Mexico in 1997 and, as demand for ammonia plummeted, the closing of plants at the petrochemical complex of Cosoleacaque (Duhalt 2011). These conditions led to a growing dependence on food imports, to the level that we see today.

Correspondingly, urea imports skyrocketed in that same period of time (see Figure 5). In 1995, for example, Mexico imported a mere 9,374 metric tons of urea,¹⁴ but in 2000 the figure rose abruptly to 1,239,495 metric tons. In the same period of time, imports of nitrogen fertilizers in general grew from 82,777 metric tons to 1,421,559 metric tons. These numbers indicate that it took Mexico only a few years to dismantle its nitrogen fertilizer industry and become a net importer. Exports of urea from Mexico vanished by the turn of the century. Due to high levels of ammonia production in 1996, urea producers managed to export 679,196 metric tons, but in line with the trend set by Cosoleacaque, exports had shrunk to 6,907 metric tons by 2000. Similarly, nitrogen fertilizer exports declined from 1,034,163 metric tons to 38,917 metric tons, showing

¹⁴ A year earlier, however, imports stood at 285,080 metric tons (UN Comtrade Database 2014).

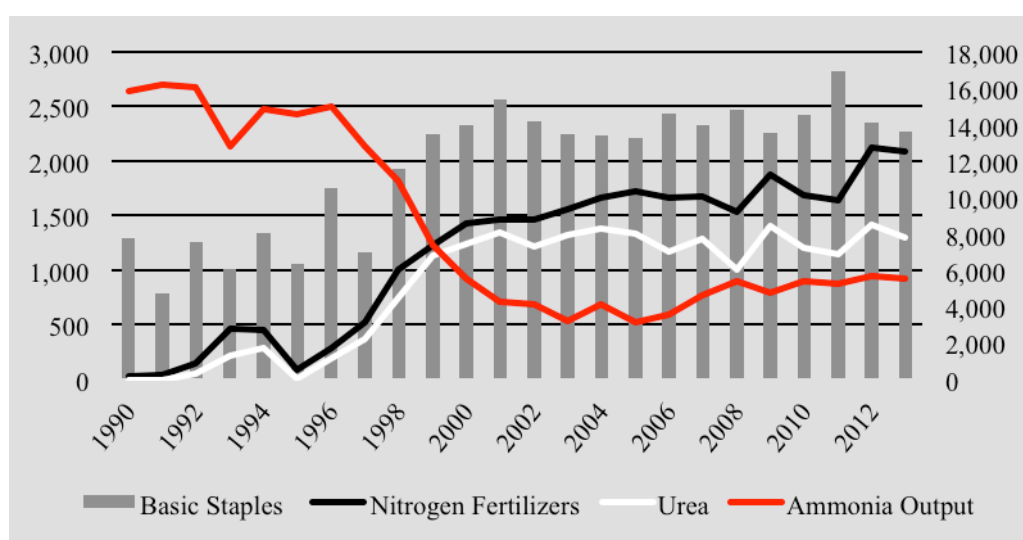
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that the country also experienced a huge blow in the production of ammonium nitrate and ammonium sulphate—the other two important nitrogen fertilizers (UN Comtrade Database 2014).

To make matters worse, during the 1990s, the petrochemical complex of Cosoleacaque and nitrogen fertilizer firms were among the hardest hit by fluctuations in the price of natural gas, and the following decade was equally challenging as ammonia output continued to decline. In 2005, PEMEX reported to have yielded 514,000 metric tons—its lowest level—though it bounced back in 2013 as output reached 922,000 metric tons. From 2000 to 2012, prices per ton grew by a factor of almost five—an indication that conditions for the fertilizer industry failed to improve (PEMEX 2014a; PEMEX 2007). Imports of urea consistently remained above the million mark from 2001 to 2012, growing from 1,342,833 to 1,424,995 metric tons.¹⁵ The same was the case for nitrogen fertilizers, which expanded from 1,459,037 to 2,124,069 metric tons in that period (UN Comtrade Database 2014).

Figure 5. Imports of Basic Staples, Nitrogen Fertilizers, and Urea Vis-à-vis Ammonia Output, 1990–2013

In thousands of metric tons; basic staples measured on right-hand vertical axis



Source: UN Comtrade Database 2014; PEMEX (2014, 2013, 2002)

¹⁵ In 2013, imports of urea stood at 1,304,650 metric tons (UN Comtrade Database 2014).

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This scenario is the result of policies such as the government's decision to increase the prices of natural gas. This step led to the eventual breakdown of the domestic ammonia-urea supply chain. More recently, despite the greater availability of low-priced natural gas in the United States, PEMEX's petrochemical complex in Cosoleacaque is unable to take advantage of US natural gas because Mexico failed to invest in sufficient infrastructure to import natural gas to make up for its production shortage. Mexico's government now intends to reverse this chain situation by implementing energy reform and increased investments in infrastructure.

Up until now, this paper has focused on establishing the degree to which production of ammonia and imports of nitrogen fertilizers in general are interconnected. Figure 5 demonstrates this relationship and supports the argument that the drop in ammonia production is paralleled by the level of imports of nitrogen fertilizers in general and urea in particular. However, Mexico's imports of nitrogen fertilizers are subject to not only fluctuations in ammonia production but also a complex set of variables, including the gap between domestic and international prices of natural gas and trade liberalization (Ávila 2001).

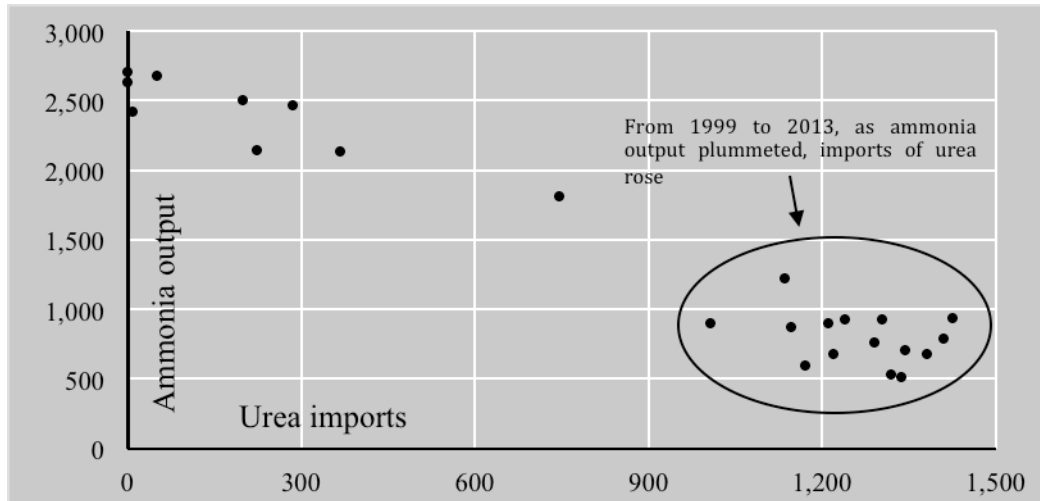
Figure 6 shows the nearly perfect linear correlation between ammonia output and urea imports. We can see that ammonia output (Y) at Cosoleacaque and imports of urea (X) from 1990 to 2013 have a strong negative correlation of -0.9731, indicating that a drop in variable Y is proportionally mirrored by a surge in variable X.¹⁶

¹⁶ A similar exercise was carried out for ammonia output and nitrogen fertilizers, resulting in a strong negative correlation of -0.9463.

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Figure 6. Linear Correlation between Ammonia Output and Urea Imports, 1990–2013

In thousands of metric tons



Source: PEMEX (2014a; 2013a; 2002) and UN Comtrade Database

One of the conclusions to be drawn from this analysis is that affordable ammonia has a positive impact on urea production. Therefore, in order to decrease Mexico's dependence on imports, policymakers must prioritize the upgrading of facilities at the petrochemical complex of Cosoleacaque. The significance of enhancing the supply of natural gas is fundamental. The government's measures clearly point in that direction—to ensure a strong supply of natural gas, first through imports from the United States by prioritizing the construction of pipelines crossing the US-Mexico border, and then through domestic production by inviting private and foreign investment in the energy sector.

Mexico's Strategy to Revive Domestic Urea Production

As mentioned in the introduction, President Peña Nieto's administration (2012–2018) intends to link the natural gas supply to ammonia and urea production in the state of Veracruz by restoring the Cosoleacaque plant. This leads to the question: What is the strategy of the government and PEMEX? First, it must be recognized that expansion of the natural gas pipeline network is thought to provide a solid base upon which other productive projects can be developed. Ammonia production at the petrochemical complex of Cosoleacaque is a case in point. Operations at Cosoleacaque have long relied on just two plants due to a combination of high

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prices and reduced availability of natural gas, as discussed earlier. However, in October 2012, PEMEX resumed production at a third plant within the Cosoleacaque complex, partly motivated by the low prices of natural gas in the United States. The Los Ramones natural gas pipeline project (numbers 17, 18, and 22 in Figure 4) is also projected to ease supply bottlenecks in segments of the national system of pipelines and free capacity to handle more natural gas in pipelines reaching southern Veracruz, where the Cosoleacaque complex is located. PEMEX estimates that ammonia facilities that have been idle for a decade and a half could now be upgraded and quickly put back to work if the natural gas supply is guaranteed.

At the same time, the 2014–2018 National Infrastructure Plan (NIP) considers the rehabilitation of the fourth ammonia plant at the Cosoleacaque petrochemical complex as central to this strategy. Moreover, in order to restore the output levels stipulated in the original design of Cosoleacaque, the NIP is also considering expanding the storage and distribution capabilities in the complex. Rehabilitation of the ammonia plant and its ancillary services is estimated to conclude in 2015¹⁷—in line with the completion of the Los Ramones project (Presidencia de la República 2014b).¹⁸ Clearly, these components—an expanded pipeline network to ensure the required natural gas supply, the rehabilitation of several ammonia production plants on the complex itself, and the expansion of ammonia storage and distribution facilities—are all part of a greater design to tackle what Mexico today considers a major problem: its excessive dependence on imported food staples.

There are other components in this design. PEMEX’s plans to increase ammonia output include a proposal to reactivate production of nitrogen fertilizers at Agronitrogenados—a fertilizer plant located about 17 miles from Cosoleacaque, which PEMEX acquired in January 2014 and which has the capacity to yield 990,000 metric tons of urea.¹⁹ Agronitrogenados ceased operations in 1999 in the midst of natural gas price fluctuations, but on June 6, 2014, PEMEX CEO Emilio Lozoya began the plant’s rehabilitation, announcing that the plant, once refurbished, would allow

¹⁷ Altogether, the investment of PEMEX in upgrading ammonia production at Cosoleacaque is reported to reach MX\$2.58 billion (Presidencia de la República 2014c).

¹⁸ It must be noted that the Los Ramones project is made up of Phase 1 (number 17 in Figure 4) and Phase 2 (numbers 18 and 22), with the latter becoming operational in December 2014, as reported by PEMEX (PGPB 2014) and media outlets.

¹⁹ PEMEX invested US\$475 million to acquire the plant (PEMEX 2014b).

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the petrochemical complex of Cosoleacaque to utilize 100 percent of its installed capacity (PEMEX 2014b).

Prospective production of urea must be contextualized, however. PEMEX estimates that Agronitrogenados, once it reaches full production capacity, can potentially substitute for more than US\$400 million worth of imports, significantly reducing the country's dependence on urea imports (PEMEX 2014b). That figure is encouraging, since the value of imports in 2013 totaled US\$498 million, according to Mexico's Institute of National Statistics and Geographical Information (INEGI 2014). In regards to tonnage, the impact is equally significant. With imports standing at 1,424,995 metric tons in 2012 (UN Comtrade Database 2014), Agronitrogenados alone may be capable of replacing about 70 percent of all imports from the United States.²⁰

In light of this evidence, it can be argued that Mexico is closer to producing affordable fertilizers for its agricultural sector—a turnabout from its policy of market integration with North America after NAFTA. The deadline set by policymakers is 2015, but the completion of rehabilitation works remains to be seen, chiefly in the case of Agronitrogenados. Energy pundits estimate that the rehabilitation of urea facilities may take at least two years (Bueno Torio 2014). Furthermore, the need for the Los Ramones pipeline to be completed in time is crucial. If the government implements its strategy successfully, Mexico could reduce its dependence on imports of basic food staples in the foreseeable future, which would be the most noteworthy result of reactivating nitrogen fertilizer production.

At first glance, it is evident that Mexico's government knows what path to follow to boost ammonia and urea production. However, several external factors may jeopardize the implementation of this strategy. The first is related to fluctuations in the price of natural gas in North America. If prices rise to the point of making urea production less competitive than

²⁰ PEMEX also has ammonia facilities in Camargo, Chihuahua, and Salamanca, Guanajuato, but these are out of work since the late 1990s and early 2000s. Privately owned nitrogen fertilizer plants are located next to these ammonia plants and have been idle since around the same period. If the expansion of the pipeline network depicted in Figure 4 encourages PEMEX to restart ammonia production in Salamanca and Camargo, it is understood that reactivation of urea plants will be seriously considered. Furthermore, with the Gasoducto del Noroeste becoming operational between 2014 and 2016, investors project to erect a fertilizer plant (Gobierno de Sinaloa 2014). If all this materializes, Mexico's dependency on urea imports might soon vanish, and it may even become a net exporter.

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imports from gas-rich countries such as Russia and Ukraine, imports would continue to be an attractive option to meet domestic demand. Another scenario to consider is the extent to which natural gas demand in the United States—which is likely to grow in the years to come, as user industries increase capacity due to competitive manufacturing costs compared to those in other advanced economies and China²¹—may hinder supply to Mexico. Policymakers must monitor external factors that pose a threat to the plan to revive urea production in the country.

Imports of Basic Food Staples

As this paper has established, the strategy depicted above is part of a broader set of policies to strengthen Mexico's food sovereignty. What is clear from our analysis, however, is that Mexico's inability to produce nitrogen fertilizers can be distinguished as one of the many drivers behind growing imports of basic staple foods.

Mexico now intends to reverse that situation, as it becomes increasingly uneasy about its food import dependence on the United States. Therefore, it should come as no surprise that the current administration is taking clear steps to reverse that dependence. In November 2013, at the inauguration of the 30th Assembly of the National Agricultural Council (CNA), Mexico's President Enrique Peña Nieto spoke to the audience about the government's seven strategies to enhance domestic agricultural production. The increased availability of fertilizers is central in this (Presidencia de la República 2013). For Peña Nieto, increasing agricultural production puts Mexico on the path to ease its dependency on imports of basic staple foods—most of which come from the United States. He seems to be well aware that the Food and Agricultural Organization of the United Nations (FAO) considers food sovereignty in jeopardy when countries import more than 25 percent. In Mexico's case that number stands at 43 percent of domestic consumption, a level considered unacceptable by the Mexican government (CVASF 2014a). Out of all the basic staple foods considered in this paper—corn, rice, beans, wheat, and sorghum—corn deserves particular consideration. In 2012, corn represented 67.42 percent of Mexico's overall imports of basic staples (UN Comtrade Database 2014).

²¹ It is estimated that the manufacturing cost competitiveness of the United States has benefited in the last decade from higher productivity per worker and inexpensive energy, while China's has rapidly eroded thanks to wage inflation (Sirkin, Zinser, and Rose 2014; Sirkin, Zinser, and Rose 2013).

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The rise in food imports was driven largely by the rapid increase in corn imports over the last two decades. From 1984 to 1993, imports represented 15 percent of domestic production. One year before NAFTA came into force, Mexico imported 210,643 metric tons, and domestic output reached 18,125,263 metric tons—imports represented just 1.16 percent of domestic production. In 1994, things changed dramatically; imports reached 2,746,638 metric tons—13 times the number in the previous year. On the other hand, output remained strong at 18,235,826 metric tons. Fast forward to 2012, and corn imports stand at 9,515,074 metric tons—a figure 45 times larger than in 1993 and accounting for 43.1 percent of domestic production.²² In contrast to the rise in imports, production from 1993 to 2012 grew just 21 percent. It can be concluded that consumption in Mexico grew significantly, but Mexican farmers failed to meet demand. In 2012, Mexico purchased 8,364,783 metric tons from US farmers—or 88 percent of total corn imports (UN Comtrade Database 2014; SAGARPA 2014).

Out of the other four basic food staples, only sorghum scored production gains during the period when import dependence increased. From 1993 to 2012, production grew 170 percent from 2,581,072 metric tons to 6,969,501 metric tons. Imports, on the other hand, fell from 3,745,189 metric tons to 1,415,558 metric tons—a 62.21 percent decrease (UN Comtrade Database 2014; SAGARPA 2014). As for beans, rice, and wheat, figures indicate that import dependence grew and domestic production decreased. Production of beans, for example, shrank from 1,287,573 metric tons to 1,080,856 metric tons in the same period, while imports grew from 7,347 metric tons to 233,609 metric tons—a number 31.79 times larger than at the beginning of that period. Rice production fell 62 percent from 287,180 metric tons in 1993 to 178,787 metric tons in 2012. Imports, on the other hand, rose from 347,924 metric tons to 848,768 metric tons. Wheat production similarly fell by 8.6 percent—from 3,582,450 metric tons in 1993 to 3,274,336 metric tons in 2012, while imports grew by 20.7 percent—from 1,741,487 metric tons to 2,101,272 metric tons during the same period (UN Comtrade Database 2014; SAGARPA 2014).

President Peña Nieto clearly intends to revive Mexico's agricultural sector by making important changes to the fertilizer industry. The administration wants to see changes in the agricultural sector, with concrete plans coming in line in 2014 (Presidencia de la República 2013). The

²² In 2012, Mexico's corn production stood at 22,069,254 metric tons, according to SAGARPA (2014).

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rationale behind the integration of Mexico's natural gas supply with ammonia and urea production must be understood in light of Mexico's increasing unease with its food dependence on the United States and its plans to reverse that trend.

Policy Changes and Recommendations

The Peña administration's renewed interest in gas transport infrastructure can be attributed to the potential opportunities that energy reform opens up in key productive sectors, such as power generation, manufacturing, and petrochemicals. Policymakers are aware of the fact that the existing bottlenecks in natural gas supply and the limited scope of the pipeline network may harm the potential benefits of energy reform. This concern, along with future demand, has ignited renewed interest in investing in pipeline infrastructure.

Under this scenario, we direct our attention to the policies resulting from energy reform. The creation of the CENAGAS²³ (National Center for Natural Gas Control), the regulator in charge of operating the national network of gas pipelines and storage infrastructure, is viewed as a crucial step in providing certainty to the sector's players. Prior to the reform, PEMEX operated the infrastructure, but it prioritized its own needs and those of the power sector, leaving the needs of industrial consumers aside. This approach is no longer tenable. The energy reform transfers the management of the natural gas infrastructure to CENAGAS so that producers, distributors, and end users will have non-discriminatory access to gas transport and storage capacity. The expectation is that competition in mid-stream activities (transport, storage, and distribution of natural gas) will increase. To achieve this, CENAGAS must be granted ample faculties to comply with its mandate and avoid providing preferential treatment to particular players. CENAGAS must regulate natural gas markets, in which PEMEX is the major player, without favoritism.

In the early stages of the reform, PEMEX may enjoy a somewhat advantaged position in the use of the natural gas transport and storage infrastructure, but this will change as more firms enter

²³ Centro Nacional de Control del Gas Natural. Its creation was decreed on October 28, 2014, as published in Mexico's official gazette (Secretaría de Gobernación 2014).

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into the Mexican market. To accommodate the growing needs from all players involved, including those from PEMEX, projected expansion of the national network of pipelines must be a priority for the Peña administration, and CENAGAS needs to be cautious in crafting and executing policies to match demand and supply.

On the supply side, challenges remain. While imports of natural gas can increase availability in the near future, greater domestic output through the development of unconventional and conventional reserves is necessary in the long run. But first, Mexico must overcome obstacles such as the lack of infrastructure to connect production with consumer centers. For example, how can natural gas extracted from shale deposits in Coahuila be transported to industrial clusters in central Mexico and other regions? So far, the construction of pipelines is centered on imports from the United States (see Figure 4). As the energy reform advances, policymakers must turn their attention to developing adequate infrastructure to transport additional gas output to where demand exists.

Low gas prices in the United States represent another issue, with an average price of US\$3.85 per million Btu since 2010²⁴ (EIA 2014a). These low prices ultimately result in thinner profit margins, and potential investors may question the convenience of developing shale gas reserves in Mexico, given that domestic demand can be met through imports. To make the sector more attractive, regulators need to craft policies and provide incentives for firms to develop innovative business models. Mining firms whose extractive processes facilitate gas production may now become suppliers of the commodity, even though they were banned under previous regulations. Petrochemical firms, whose industrial processes run on natural gas, may integrate vertically and seek to secure supply by developing gas fields. However, in order for scenarios like these—designed to boost natural gas supply—to be seen as an investment opportunity, the existence of clear, fair rules monitored and executed by capable regulators is required.

²⁴ Average price from January 2010 to October 2014.

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