Agora Industry

Agora Energy Transition

Argentina as a hub for green ammonia

A forward-looking development strategy for addressing the global energy and climate crises

POLICY BRIEF

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Preface

Dear reader,

Russia's war against Ukraine has exacerbated the global energy and climate crises. Natural gas prices are record high, affecting certain commodities. Food prices in particular have skyrocketed on the heels of lower crop exports from Ukraine and Russia and higher prices for nitrogen-based fertilisers (due to the natural gas inputs required to manufacture ammonia) as well as global crop losses due to drought made worse by the climate crisis.

Green ammonia could play an important role in mitigating the global energy and climate crises by reducing reliance on fossil fuels to manufacture fertilisers. A lower demand for natural gas as an industrial feedstock for fertiliser production would for its part, to a certain extent, mitigate food price volatility. Thanks to promising conditions for green ammonia production, Argentina has a unique opportunity to become a key player in the global production of green fertilisers.

This paper proposes potential strategies that Argentina could adopt to harness its energy resources and develop a sustainable domestic fertiliser industry. With international support, Argentina could tap the potential offered by renewable hydrogen to position itself as one of the global hubs for green ammonia and other hydrogen-based products. This shift would not only generate significant socioeconomic benefits in Argentina but would also contribute to the transition to climate neutrality globally.

I wish you a pleasant and informative read.

Yours sincerely,

Frank Peter
Director, Agora Industry

Key findings at a glance:

1. **The global fossil energy crisis is affecting global fertilisers production due to rising costs for ammonia.** Heavy reliance on fossil gas in fertiliser production makes the industry carbon-intensive and vulnerable to price shocks as seen currently.
2. **Green ammonia can decouple fertilisers production from natural gas.** Producing fertilisers with renewable energy instead of fossil fuels would help reduce greenhouse gas emissions and increase the sector's resilience. However, the price gap between fossil and renewable hydrogen is a key challenge for Argentina to scale up green ammonia production.
3. **Argentina has unique conditions to address the crisis in a sustainable way.** Argentina could build up its ammonia production capacity using the existing natural gas reserves, while developing its vast renewable hydrogen potential in order to switch to green ammonia as fast as possible. This could create jobs, reinforce food security, and help to the decarbonise industry.
4. **The international community would gain from supporting Argentina's efforts to enhance the production of green ammonia and fertilisers.** International support and investment can help to overcome economic challenges in the production of green ammonia, guaranteeing a sustainable development of Argentina's industrial sector. Countries worldwide could benefit from a more diversified fertiliser supply chain.

Content

Introduction

Russia's invasion of Ukraine has had dire humanitarian, geopolitical and economic consequences. Russia and Ukraine are among the world's top ten exporters of grains. Moreover, Russia is the world's largest exporter of fertilisers and of natural gas to Europe, where 2.4 percent of total gas consumption is used to produce another 9 percent of global nitrogen-based fertilisers (Fertilizers Europe, 2022). War-related sanctions and supply disruptions have contributed to skyrocketing energy and food prices.[1] Global fertiliser prices have tripled since mid-2020, and current record prices will have a sustained impact on global agricultural production (IEA, 2022).

Figure 1 illustrates the tight price correlation between energy, fertilisers and agricultural products. Some 4 percent of global gas demand is used to produce ammonia (IEA, 2022), a primary feedstock to produce nitrogen fertilisers such as urea. Because of such intense reliance on natural gas, global fertiliser production is also responsible for more than two percent of global greenhouse gas emissions, and thus an important driver of climate change.[2]

As the cost of natural gas can account for up to 90 percent of the cost of producing ammonia (Kenkel P., 2017), price volatility in natural gas markets propagate to the fertiliser industry and subsequently to food prices, contributing to instability in agricultural markets (Uçak et al., 2022).

Decoupling fertiliser production from natural gas markets would help bring down fertiliser prices, thus easing the pressure on global food markets. Argentina could promote the development of green ammonia production as part of a broader strategy to encourage decarbonisation and sustainable development in the country.

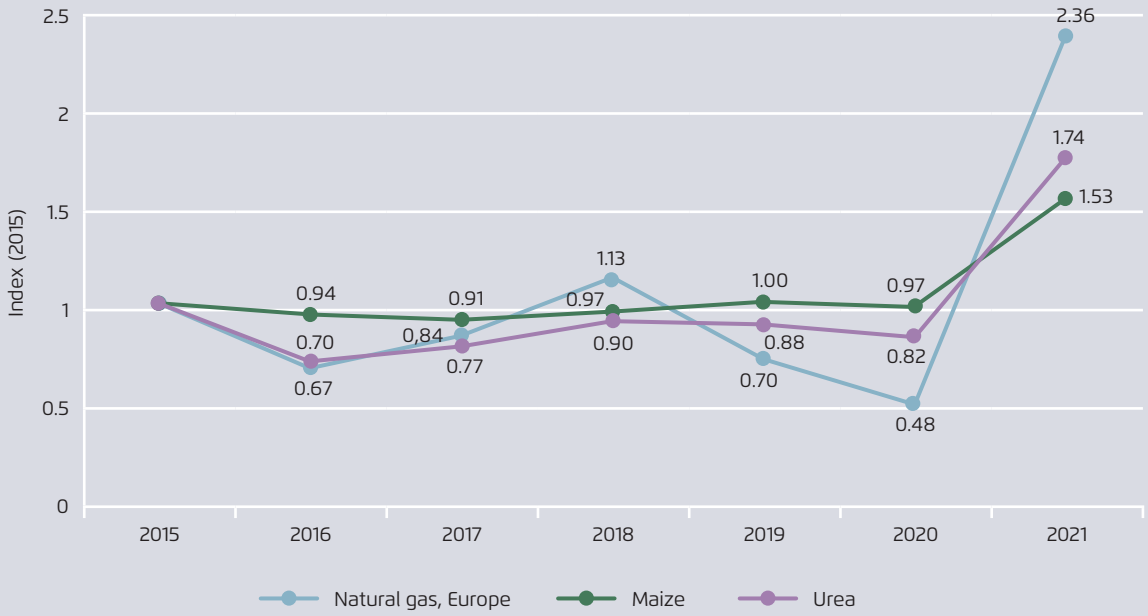
While Argentina has excellent conditions to produce renewables and renewable hydrogen (Fraunhofer, 2021), the country has been slow to tap this potential. In general, the development of domestic energy infrastructure has been slow, thus contributing to high energy imports and domestic energy scarcity. In contrast to the challenges in the energy sector, the country is one of the world's most important food producers and exporters. However, the Argentinian agricultural industry is heavily dependent on fertiliser imports, where nitrogen-based fertilisers are widely used (38 kg per hectare of cropland; see FAO, 2022b) and represent a substantial share of production costs.

This paper highlights opportunities for Argentina to advance its domestic development while also helping to alleviate the global "polycrisis" of skyrocketing energy prices, food price volatility, and climate change. Specifically, the country can develop strategies that (1) promote the local production of ammonia, based on increasing volumes of renewable hydrogen; (2) boost sustainable fertiliser manufacturing capacities; and (3) position the country as a major exporter of green ammonia.

1 The causes of the current food price crisis are multifaceted and not solely attributable to the war.

2 Nitrogen-based fertilisers have also a large emissions impact related to their application, resulting from NOx direct soil emissions. Accordingly, mitigating conventional and synthetic fertiliser use is important for curbing climate change. However, discussion of climate-friendly agricultural practices goes beyond the scope of this document.

Natural gas, urea, and maize price index (1 = 2015) Figure 1



Based on World Bank (2022a)

An opportunity to enhance sustainable and economic growth in Argentina

Argentina is the world's third largest exporter of agricultural commodities after the US and Brazil. In the 2020/21 accounting year, the country exported about 100 million tonnes of agricultural commodities (Bolsa de Comercio de Rosario, 2022). In 2020, exports of soybean, sorghum, maize, and wheat generated 10.3 billion US dollars in revenues (FAO, 2022), and agriculture accounted for 6 percent of Argentinian GDP (World Bank, 2022b). Going forward, the country has the potential to further expand domestic agricultural production.[3]

However, to buffer the country's agricultural investments from fluctuating energy and imported fertiliser prices, Argentina should consider measures to significantly expand domestic fertiliser production. Capitalising on future opportunities for the export of green ammonia could further serve to prove the business case for domestic production.

As a first step, Argentina could develop its natural gas resources as a bridge technology to produce conventional ammonia. This would encourage the development of gas transport infrastructure and thus stabilise the gas supply grid. However, any investment in new ammonia production facilities should require renewable-hydrogen readiness, and a certain ratio of green ammonia production.

While green ammonia is still more expensive than its conventional counterpart, a global market for green ammonia is emerging because of decarbonisation policies in Europe and Japan, as well as green fuel

3 The expansion of agricultural production could focus more on food and not animal feed products, contributing to the diversification of the global food supply chain. Additionally, it should consider important issues related to sustainable farming, soil conservation, and biodiversity protection, among other factors. However, such considerations exceed the scope of this discussion.

demand by the global shipping industry. Furthermore, Argentina has favourable circumstances to produce renewable hydrogen at low cost and could therefore produce green ammonia at lower cost than other countries. This means that Argentina could use the growing demand for green ammonia to finance the development of its renewable hydrogen economy. This would generate a range of benefits: in the short term, the expansion of renewable energy investment could induce a general reduction in electricity costs while also enhancing energy security, especially during the winter months. In addition, the increased export of ammonia and agricultural goods would generate beneficial export revenues and local employment creation. Over the long term, the cost of renewable hydrogen and green ammonia is anticipated fall below the cost of their conventional equivalents (BNEF, 2021). This would provide Argentina with additional opportunities to increase the competitiveness of its agriculture and industrial sectors.

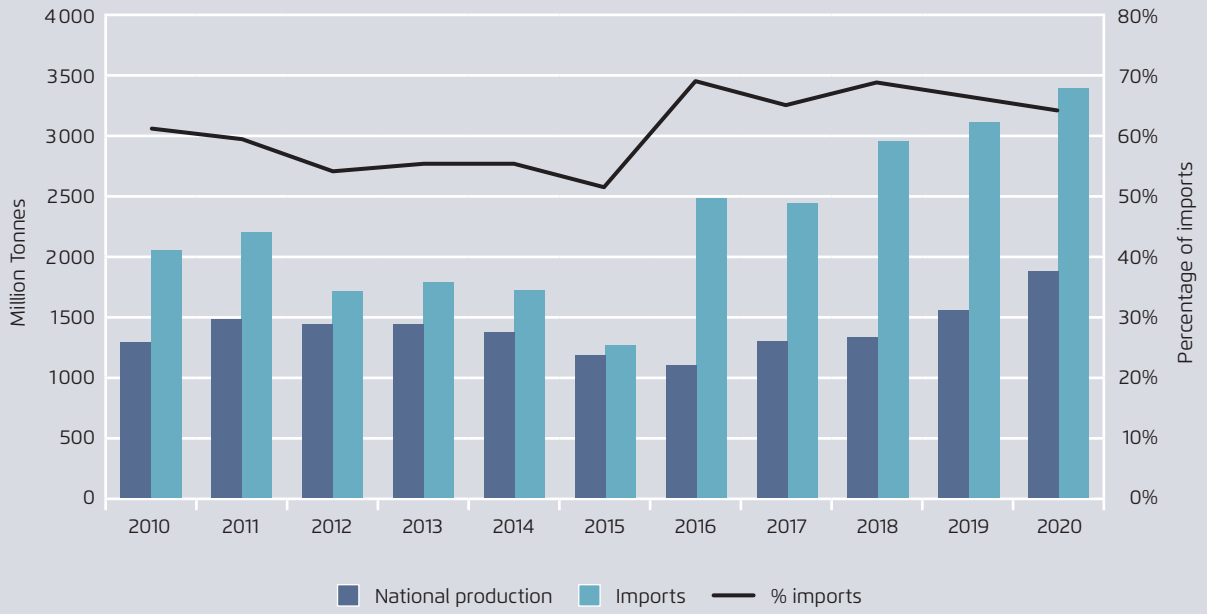
Argentina's fertiliser market relies largely on imports and conventional ammonia production

Today, Argentina operates three ammonia plants that rely on grey hydrogen from natural gas as a feedstock, see Table 1. These plants only operate at 70 percent of their installed capacity (IPA, 2019), a statistic that underscores the potential for productivity improvements in the Argentinian ammonia and fertiliser industry. Ammonia is the main feedstock in the manufacture of nitrogen-based fertilisers such as urea and ammonium nitrate, which are required for cultivating Argentina's most important agricultural products – namely, maize and wheat.[4]

As presented in Figure 2, Argentina consumed more than 5.2 million tonnes of fertilisers in 2020;

4 Soy is also an important commodity in Argentina, but it does not require nitrogen-based fertilisers.

Argentina's market balance for fertilisers, 2010–2020 Figure 2



Bolsa de Comercio de Rosario (2021)

Ammonia production plants in Argentina — Table 1

Company	Installed capacity (tonnes per year)	Feedstock
Fabrica Militar Rio Tercero[1]	12 000	Natural Gas
Bunge Argentina S.A.	115 000	Natural Gas
Profertil S.A.	790 000	Natural Gas
Austin Powder Argentina S.A.	59 000	Natural Gas

IPA (2019);
[1]) Out of operation

nitrogen-based products made up 56 percent of this total. In the period between 2010 and 2020, domestic fertiliser consumption increased 4.6 percent annually on average (Bolsa de Comercio de Rosario, 2021). As Argentina's domestic production could not keep pace with this demand growth, imported fertilisers now represent more than 60 percent of total consumption. Table 2 presents an overview of the main local fertiliser production plants in the country with their respective annual production capacity. In 2020, Argentina spent 1.1 billion US dollars on fertiliser imports. In 2021 expenditures increased to 2.3 billion US dollars, and with the high prices of 2022, the negative impact on Argentina's balance of trade will be even more significant.

Fertilisers and green ammonia are key to Argentina's energy transition

Argentina has massive energy resources that can be exploited for its socio-economic development. Today natural gas is the predominant energy source, accounting for more than 50 percent of primary energy supply and more than 60 percent of power generation (IRENA, 2022). While Argentina has significant potential to expand domestic production, the country faces challenges connecting its remote gas fields to domestic and international markets.

In addition, Argentina has vast and diverse opportunities for expanding renewable electricity generation with wind, solar, and hydropower. Argentina's renewable energy costs are currently competitive in the global context and are anticipated to decline significantly in the coming years, with some estimates forecasting a 70 percent reduction up to 2030. This makes renewable energy in Argentina ideal for hydrogen production. Argentina's renewable cost trends furnish the country with significant advantages for the development of climate neutral industry (New Climate Institute, 2020). However, transmission bottlenecks hinder the further development of renewable power generation. Consequently, harnessing the country's renewable energy potential will require significant energy infrastructure investment.

Given such promising renewable potential, it is important for Argentina to carefully assess the development of its natural gas resources ensuring that all investments are, at least in the medium term, economically favourable. At the same time, Argentina must implement policies that encourage the growth of a renewables and hydrogen-based economy – not only to fight climate change, but also to ensure long-term industrial competitiveness.

Fortuitously, the specific operational characteristics of the ammonia and fertiliser industry lend themselves to a sequential strategy that foresees natural gas development paving the way for the adoption of more sustainable alternatives.

Main fertilisers production plants in Argentina — Table 2

Starting year of operation	Company	Products	Annual production capacity (tonnes)
2001	Profertil S.A.	Urea	1 320 000
2004	Bunge Argentina S.A.	Ammonia Thiosulfate (TSA)	140 000
2006	Mosaic Argentina S.A.	Simple Superphosphate	240 000
2008	Bunge Argentina S.A.	Simple Superphosphate	180 000

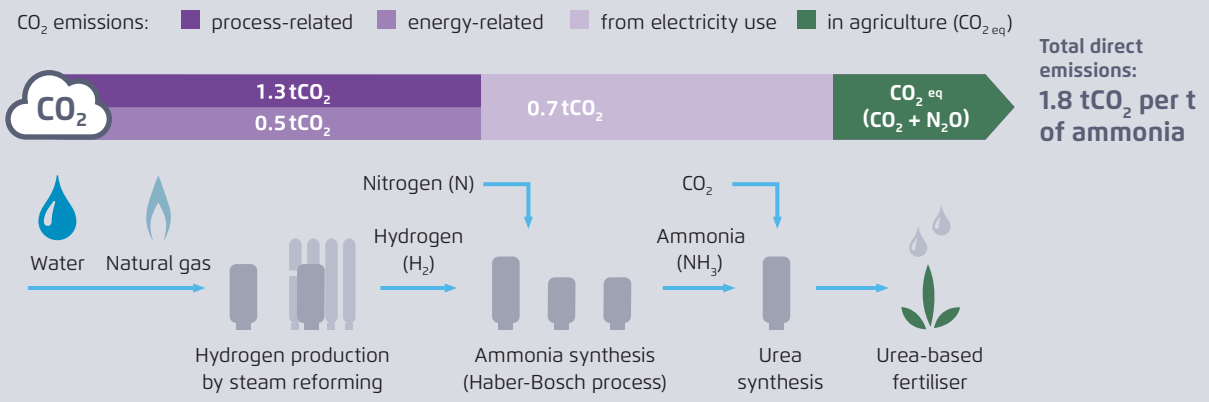
Bolsa de Comercio de Rosario (2021)

Specifically, ammonia production relies on the Haber-Bosch process, which is flexible in nature. As visualised in Figure 3, the process allows ammonia to be produced from a mixture of nitrogen and hydrogen. Traditionally, this gas mixture is produced by subjecting natural gas to steam methane reforming. This process emits about 1.8 tonnes of CO_2 per tonne of ammonia produced, making ammonia synthesis a significant contributor to global GHG emissions.

An alternative production technique is to split water into oxygen and hydrogen using renewable electricity. The hydrogen is then combined with nitrogen captured from the air to feed the Haber-Bosch process. If only renewable electricity is used in the process, the resulting ammonia is climate neutral and can be used as a renewable fuel and feedstock in the chemical and fertiliser industries.

Ammonia production is flexible in that hydrogen coming from the steam reforming of natural gas as well as hydrogen from water electrolysis can be combined. The Haber-Bosch process is fully adaptable regarding the origin of the gas mixture. If new plants are designed for this flexible operation, they can produce green and conventional ammonia to

Conventional, natural gas-based ammonia synthesis — Figure 3



Agora Energiewende and Wuppertal Institute (2021)

accommodate varying requirements. Accordingly, it would be produced green ammonia for export as well as conventional ammonia for domestic uses, insofar as it remains cheaper than the green alternative.

In the case of urea, which is produced by combining ammonia with CO_2, conventional production pathways sources fossil CO_2 from the steam methane reforming of natural gas. Once the plant has fully shifted to production based on renewable hydrogen, fossil CO_2 will no longer be available and sustainable biogenic CO_2 source (climate-neutral) must be identified as a replacement.

Given the current maturity of green ammonia production technologies and associated market demand, green ammonia is more expensive than its conventional equivalent, mainly due to the price differential between fossil and renewable hydrogen. However, in situations in which renewable electricity can be generated at low cost, such as in Argentina, or where natural gas and carbon prices on CO_2-emissions are high, such as in Europe, the price gap is much smaller.

To close this gap, it will be important to develop new large-scale production plants, as this will further reduce the cost of renewable energy and hydrogen production, improve the efficiency of electrolysers, and encourage the construction of infrastructure for hydrogen and ammonia transport and storage.

A range of supportive policies and financial mechanisms have come online in recent years to promote investment in large-scale green ammonia production facilities. One example is the *H2Global Foundation*, which has recently started running auctions for the purchase of green ammonia – as well as other renewable hydrogen-based products – at a premium that will cover the effective cost of green production. Purchase contracts will have a ten-year term, thus providing investors with assurance they can recover their costs. The green ammonia will then be sold by *H2Global Foundation* in European markets via short term annual auctions. In the event the resale cost is lower than the purchase cost, the German government will cover the price differential. A first auction to purchase ammonia was launched in November 2022.

Another instrument to incentivise the production of renewable hydrogen-based products are binding targets, such as those defined by the European Commission for the use of green hydrogen as a transport fuel or feedstock in the chemicals industry. For instance, as part of the third revision of the European Renewable Energy Directive (RED III), policymakers aim to set a 2030 renewable hydrogen target for the transport sector of at least 2.6 percent (including hydrogen-based fuels). RED III has also set a 2030 target of 50 percent renewable hydrogen (including hydrogen-based fuels) for final energy and non-energy purposes in industry (EC, 2021). Such policy instruments will create a viable market for green ammonia as well as other hydrogen-based products (such as methanol or e-kerosene for aviation).

Finally, the new international carbon market mechanisms that are being developed under Article 6 of the Paris Agreement could help to promote green ammonia. While policymakers are still negotiating the rules that will govern the development and registration of projects, as well as the trading of so-called Internationally Transferred Mitigation Outcomes, the mechanism may be adequate for promoting the domestic use of green ammonia, rather than encouraging its export.

However, all the support mechanisms discussed in the foregoing represent "performance-based" subsidies, and do not directly assist with investments required to construct new ammonia plants or retrofit existing ones. Unfortunately, mobilising investment capital is a major challenge for Argentina, due to its high-risk investment environment and high cost of capital.

However, Argentina has a unique opportunity to leverage the support of the international community and embark on a strategic effort to develop a domestic green hydrogen and fertiliser industry. Such a policy effort would not only generate significant benefits for the Argentinian economy, but also help to ameliorate the current "polycrisis" marked by high energy prices, high food prices, and the growing climate change threat.

Several arguments can be leveraged to encourage the support of international investment in the Argentinian green ammonia and fertilisers economy:

- → Developing domestic fertiliser production in Argentina would increase global fertiliser availability, and, by extension, lower its cost, thus reducing negative impacts on food production in other countries.
- → Scaling up the production of ammonia in Argentina would reduce demand for natural gas in other regions and thus help to alleviate the international energy crisis. It would also help Argentina to stabilise its gas market, and thus support economic recovery.
- → A swift transformation to the production and possible export of green ammonia would further reduce international gas consumption and contribute to global GHG reduction efforts.[5]

In this way, Argentinian investment policy should take into account the unique opportunity of the present moment to position the country as one of the global hubs for sustainable agriculture, green ammonia, and other hydrogen-based products. As part of an associated long-term strategy, Argentina should first seek to reduce its dependency to fertiliser imports, while rationalising domestic fertiliser consumption. As a next step, Argentina should develop its fertiliser industry in order to fully cover domestic demand; this would pave the way for gradually increasing exports of ammonia, fertilisers, and other renewable hydrogen-based products.

Strategic steps in addressing the energy and climate crises

Rising to the challenges posed by the current polycrisis necessitates the development of a strategic plan that elaborates sustainable and consistent measures over the short, medium, and long term. To be sure, the development of such a strategy will require ample dialogue with all relevant domestic and international stakeholders. Accordingly, this policy brief highlights several considerations of importance to such discussions.

Over the short term, a focus should be placed on measures that reduce and optimise domestic fertiliser consumption, without compromising agricultural productivity. According to the World Bank article (World Bank, 2022c), key measures include:

1. **Ensuring the efficient use of fertilisers:** Incentives for wasteful consumption must be substituted by policies that promote efficient nitrogen use above 90 percent.[6]
2. **Mitigating financial distress among actors in the fertiliser value chain:** As a result of soaring prices, the financing needs of producers, traders, and farmers have tripled. Short-term credit facilities and guarantees, mobilised with the support of international development institutions, may be necessary to avoid further restrictions. This should include access to climate financing funds.
3. **Promoting innovation:** Agricultural productivity per kg of fertiliser can be increased through the

5 This only considers upstream emissions related to the production of nitrogen-based fertilisers. Further emissions reductions in the use of fertilisers lie outside the scope of this paper.

6 "Nitrogen use efficiency" is an established metric in nitrogen management. The efficiency refers to the ratio between the nitrogen input (in the form of fertilisers) and the converted nitrogen output (in the form of crops). Higher nitrogen efficiency avoids the overuse of fertilisers in crop production.

adoption of innovative technologies that ensure the precise selection and dosing of fertilisers. Precision agriculture and fertigation are two examples of techniques that are already being introduced in Argentina by cost-conscious producers. Other important strategies are to improve soil health and supplement conventional fertilisers with viable bio-fertilisers.

Yet another short-term measure would be to investigate whether the production of existing ammonia plants can be increased. In the event their capacity or productivity can be optimised through incorporation of renewable hydrogen as a feedstock, international investment support could be solicited for associated retrofitting measures.

Over the medium term, it will be crucial to expand Argentina's fertiliser production capacity with a carefully balanced strategy that relies on natural gas as a bridge technology, as well as renewable hydrogen. While the export of renewable hydrogen appears to be an attractive opportunity, it will be important for Argentina to prioritise the replacement of fertiliser imports. An ideal solution would be to find international support mechanisms that cover the incremental cost of green ammonia production for local use as this would align with the objective of reducing GHG emissions while also reducing fertiliser imports.

In the event such international support cannot be mobilised, new ammonia production facilities could also be developed to initially use natural gas as a bridge technology. However, their design and siting must accommodate a gradual transition to renewable hydrogen.

Over the long term, Argentina has an opportunity to finance the expansion of its renewable energy and hydrogen production capacity to produce ammonia, fertilisers, and other renewable hydrogen-based products for export to Europe and other countries.

In the case of ammonia, export to Europe is of special interest. The *REPowerEU* plan seeks to significantly reduce European consumption of natural gas, in part by replacing with imports a share of domestic ammonia production (which currently stands at 19 million tonnes annually).

In the foregoing, we spotlighted the opportunities for Argentina offered by adoption of a comprehensive strategy to significantly expand domestic fertiliser production with the aim of first achieving independence from fertiliser imports and then becoming a major exporter of green ammonia. Such a strategy would reap significant socioeconomic benefits for Argentina, including higher agricultural productivity, increased domestic value and job creation, an improved balance of trade, and lower GHG emissions, especially in the industrial sector.

Yet the international community would also stand to benefit from such a strategy. Expansion of Argentinian fertiliser production would ease the upward pressure on food prices. At the same time, the production of green fertilisers would reduce demand for natural gas while positioning Argentina as a reliable source of cost-competitive green ammonia and other renewable-hydrogen-based products. In this way, Argentina could make an important contribution to addressing the climate crisis.

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