BEYOND LNG:

Coal-to-Chemicals as the Strategic Shield for ASEAN+4 Food Security

By: Dr. Joseph Fournier, Rockyford, Alberta (https://josephfournier.substack.com/)

EXECUTIVE SUMMARY

The closure of the Strait of Hormuz amid the escalating conflict in the Persian Gulf has exposed a stark vulnerability at the heart of Asia's energy and food systems. With over 80% of LNG shipments through this choke-point destined for Asian markets, the shutdown of this vital corridor has sent shockwaves throughout Asian markets deeply dependent on imported LNG. Iran's drone and missile strikes have turned Hormuz into an active conflict zone, underscoring how fragile global energy routes have become. Against this backdrop, coal gasification has re-emerged not as an industrial relic but as a strategic lifeline. For the ASEAN+4 nations, home to 3.7 billion people, coal-derived hydrogen is increasingly recognized as the only domestically controlled, geopolitically insulated pathway capable of sustaining ammonia and urea production. Fertilizer is a national-security asset: without it, crop yields collapse, and without stable hydrogen supply, fertilizer production collapses. Coal-rich nations such as China, India, and Indonesia have already embraced coal-to-fertilizer as a shield against LNG volatility, maritime chokepoints, and global price shocks.The message is clear. In an era where maritime trade can no longer be assumed safe or stable, coal gasification provides the ASEAN+4 region with resilient, affordable, and sovereign control over the chemical foundations of food production. As global supply chains fracture, coal-to-chemicals is not merely an energy strategy, it is the backbone of food security for billions.

1.0 INTRODUCTION

The Green Revolution stands as one of the most consequential turning points in human history. The invention and global diffusion of the Haber–Bosch process fundamentally altered the relationship between population, agriculture, and energy. Before synthetic nitrogen fertilizers, global food production was constrained by the limited availability of fixed nitrogen from guano, manure, and biological fixation. The industrial synthesis of ammonia broke this constraint, enabling agricultural yields to rise dramatically and supporting the explosive growth of global population from 1.6 billion in 1900 to more than 8 billion today [1]. Today, more than half of humanity is fed by nitrogen fertilizers derived from hydrocarbons. If coal and natural gas were banned as feedstocks for ammonia and urea, global population would collapse by roughly 50%—a stark reminder that hydrocarbons are not merely fuels but the chemical foundation of modern civilization [2].

At the heart of this transformation lies the Haber–Bosch process, which synthesizes ammonia (NH_3) by reacting hydrogen (H_2) with nitrogen (N_2) at high temperature and pressure over an iron-based catalyst.

The process involves three major stages:

- Hydrogen generation, historically from coal or natural gas;
- Air separation, to obtain high-purity nitrogen;
- Ammonia synthesis and urea conversion, where nitrogen and hydrogen react to form NH_3, which is subsequently converted to urea via reaction with carbon dioxide [3].

This is an energy-intensive, highly endothermic process. Even if hydrogen were free, the thermal and pressure requirements of Haber–Bosch demand a dense, reliable energy source, almost always hydrocarbons. Globally, virtually all large-scale hydrogen production comes from fossil fuels. Electrolytic hydrogen, often promoted as a “green” alternative, remains uneconomic and fundamentally inflationary. Its energy return on energy invested (EROEI) is less than one on a full lifecycle basis, especially when powered by intermittent renewables such as solar PV and wind [4]. The physics are unforgiving: intermittent electricity must be overbuilt, buffered, and converted, each step adding cost and energy loss. As a result, electrolytic hydrogen cannot compete with hydrocarbon-derived hydrogen for fertilizer production without massive subsidies or regulatory compulsion.

Hydrogen from natural gas is produced through steam methane reforming (SMR) followed by water–gas shift reactions. Coal-derived hydrogen is produced through gasification, where coal reacts with oxygen and steam to form synthesis gas ($CO + H_2$). Modern gasifiers, such as entrained-flow, oxygen-blown, or steam–oxygen co-fed designs, operate at high temperatures and pressures, producing a clean, consistent syngas suitable for ammonia synthesis after CO shift and CO_2 removal [5].

For the purposes of this white paper, we will focus on the *ASEAN+4 region*, which is commonly defined as: ASEAN (10 nations) + China + India + Japan + South Korea, where ASEAN is the Association of Southeast Asian Nations. This grouping captures the full geography of Asian fertilizer production, consumption, and energy-security dynamics for a combined 3.7 billion people.

Across the ASEAN+4 region, the choice between natural gas and coal is not merely technical but geopolitical. The region is not uniformly endowed with natural gas resources, and several of its largest economies face structural dependence on imported LNG (e.g., South Korea, Japan). LNG markets are volatile, exposed to maritime chokepoints, and increasingly shaped by geopolitical risk. Coal, by contrast, is widely distributed across Indonesia, Vietnam, China, and India, and is viewed through the lens of national security rather than global commodity exposure [6]. As a result, coal gasification is emerging as a strategic pathway to secure domestic fertilizer production, reduce vulnerability to LNG price shocks, and strengthen economic sovereignty in an increasingly unstable Indo-Pacific region.

2.0 BACKGROUND

2.1 THE HABER–BOSCH PROCESS: HISTORY, EVOLUTION, AND TECHNICAL FOUNDATIONS

The Haber–Bosch process is widely regarded as one of the most transformative industrial technologies ever developed. Its origins lie in the early 20th century, when Fritz Haber first demonstrated the laboratory-scale synthesis of ammonia from atmospheric nitrogen and hydrogen in 1909. Carl Bosch, working at BASF, subsequently engineered the high-pressure reactors, catalysts, and metallurgy required to scale the process to industrial levels, culminating in the first commercial ammonia plant in 1913 [7]. This breakthrough enabled the industrial fixation of nitrogen at a scale previously unimaginable, breaking the long-standing dependence on natural nitrogen sources such as guano, manure, and biological fixation. By the mid-20th century, Haber–Bosch had become the backbone of global agriculture, enabling the Green Revolution and supporting unprecedented population growth [8].

Early Haber–Bosch plants relied primarily on coal gasification to produce hydrogen, as coal was the dominant industrial fuel in Europe. After World War II, the rise of natural gas infrastructure shifted hydrogen production toward steam methane reforming (SMR), particularly in North America, the Middle East, and parts of Europe [9]. However, in regions with limited natural gas resources, most notably China, India, and increasingly Southeast Asia, coal gasification has remained the primary hydrogen source. Today, the process continues to evolve through improvements in catalyst design, reactor metallurgy, heat integration, and air separation technologies, enabling modern plants to exceed 2,000 tonnes per day of ammonia production, with advanced designs surpassing 3,500 tonnes per day [10].

2.2 THE HABER–BOSCH PROCESS

The core reaction of the Haber–Bosch process is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta RH^\circ = -92.2 \text{ KJ/MOL}$$

This exothermic reaction is favored by high pressure (typically 150–300 bar) and moderate temperature (400–500°C). According to Le Châtelier’s principle, increasing pressure shifts the equilibrium toward ammonia formation, while lower temperatures favor the reaction thermodynamically but slow reaction kinetics [11]. Modern plants therefore employ a synthesis loop with multi-bed catalytic reactors, inter-stage cooling, ammonia condensation, and recycle compressors to maximize conversion efficiency [12].

The urea synthesis step reacts ammonia with carbon dioxide:

$$2NH_3+CO_2 \rightarrow NH_2COONH_4 \rightarrow CO(NH_2)_2+H_2O \quad \Delta RH° = +134\ KJ/MOL$$

This reaction is endothermic and requires high pressure (140–180 bar). Importantly, the CO_2 used in urea production is a by-product of hydrogen generation, meaning the carbon footprint of urea is tightly linked to the hydrogen source [13].

2.4 COAL AS BOTH FEEDSTOCK AND ENERGY SOURCE

Coal plays a dual role in ammonia production: it provides the carbon and hydrogen required to produce synthesis gas ($CO + H_2$), and it supplies the thermal energy required to drive the highly endothermic reactions of the Haber–Bosch process. Even in natural-gas-based plants, hydrocarbons remain essential for process heat, compression, and air separation. This underscores a fundamental reality: nitrogen fertilizer production is inseparable from hydrocarbon energy systems [14].

In natural-gas-rich regions, hydrogen is produced via SMR:

$$CH_4+H_2O \rightarrow CO+3H_2 \quad \Delta RH° = +206\ KJ/MOL$$

$$CO+H_2O \rightarrow CO_2+H_2 \quad \Delta RH° = -41\ KJ/MOL$$

SMR is efficient but dependent on stable natural gas supply. For ASEAN+5 nations, this is a structural vulnerability: domestic gas reserves are unevenly distributed, and LNG imports expose fertilizer producers to global price volatility [15]. Coal gasification produces hydrogen through partial oxidation and in the mass action relations shown below, both oxygen and steam are used:

$$C+O_2 \rightarrow CO+H_2 \quad \Delta RH° = -110\ KJ/MO$$

$$CO+H_2O \rightarrow CO_2+H_2 \quad RH° = -41\ KJ/MOL$$

Modern gasifiers (e.g, steam–oxygen co-fed) operate at 1,200–1,600°C and pressures of 20–40 bar. The balance-of-plant includes:

- Air Separation Unit (ASU)
- Gas cleanup (desulfurization, particulate removal)
- Shift reactors
- CO_2 removal units
- Heat recovery steam generators

Relative to SMR, coal gasification plants are more capital-intensive as they have a smaller - less complex balance of plant, but offers strategic advantages in regions with abundant coal and limited natural gas [16] and typically have a lower cost of fuel (hydrogen source). Table 1 compares the coal feed requirements on a per tonne of nitrogen fertilizer basis when the products are ammonia, urea or ammonium nitrate. These values vary by coal grade and gasifier efficiency [17].

Table 1. Common coal consumption to nitrogen fertilizer production ratios.

Product	Coal Required (tonnes/tonne product)
Ammonia	0.9-1.2
Urea	1.3-1.6
Ammonium Nitrate	0.8-1.0

3. ASEAN+5 NITROGEN FERTILIZER CAPACITY, IMPORTS, AND DEMAND TRENDS

The top fertilizer producers and consumers in the ASEAN+5 framework are shown in Table 2 and are listed in million tonnes per annum nitrogen (N):

Table 2. Top 5 producers and consumers of nitrogen fertilizer in the ASEAN + 5 region.

Country	Production (Mtpa N)	Consumption (Mtpa N)
China	48	42-45
India	17-18	20-21
Indonesia	7-8	5-6

Japan	0.8 to 1	0.8 to 1
South Korea	0.1 to 0.2	0.8 to 1

China produces ~79% of its ammonia for urea from coal gasification [18]. India remains SMR-dominant but is shifting toward coal with the Talcher plant (1.27 Mt urea/year) [19]. Indonesia is rapidly expanding coal-to-urea capacity due to declining domestic gas availability [20]. Japan and South Korea rely heavily on LNG imports and have minimal domestic fertilizer production, making them structurally dependent on global markets [21].

ASEAN+5 nitrogen fertilizer imports have grown steadily since the early 2000s due to:

- Rising population
- Dietary shifts
- Limited domestic production capacity
- Volatile LNG prices

Indonesia and Vietnam have explicitly identified LNG dependence as a strategic vulnerability in national energy plans [22].

Demand for nitrogen fertilizers in ASEAN+5 is projected to grow due to:

- Rising per capita affluence
- Population growth
- Agricultural intensification
- Limited arable land expansion

Most projections show nitrogen fertilizer demand increasing 1.5–2.0% annually through 2050 [23].

4. COAL GASIFICATION: HISTORY, EVOLUTION, AND ASIAN LEADERSHIP

Coal gasification originated in 19th-century Europe for town gas production. Its modern industrial form emerged in the mid-20th century with the development of:

- Texaco entrained-flow gasifiers

- Shell gasifiers
- GE gasification technologies

China acquired and indigenized much of this intellectual property in the 1990s and 2000s, enabling rapid domestic expansion [24].

China's coal gasification industry is now dominated by:

- ECUST
- Yankuang Group
- Sinopec engineering subsidiaries

These firms have exported gasification technology to India, Indonesia, and Vietnam [25].

Over the past decade, ASEAN+5 has seen:

- 60 new gasifiers commissioned or under construction
- Capital deployment exceeding USD 60–80 billion
- A shift toward large-scale, oxygen-blown gasifiers

China leads, followed by India and Indonesia [26].

Coal-to-chemicals, including fertilizer, has grown rapidly. Literature suggests that in China, coal-to-liquids (CTL) and coal-to-chemicals (CTC) now consume more than 400 million tonnes of coal per year, exceeding the coal consumption of the entire steel sector, which is estimated at roughly 350–380 million tonnes per year. ASEAN+5 is following a similar trajectory.

In Indonesia, coal-to-fertilizer projects are projected to consume 15–20 million tonnes of coal annually by the mid-2030s, rivaling cement sector consumption. India's coal-to-urea expansion could add another 10–15 million tonnes of annual coal demand by 2040 [28].

5.0 ECONOMICS & CO_2 EMISSION INTENSITY OF NITROGEN FERTILIZER DERIVED FROM COAL VS IMPORTED LNG

The economics of nitrogen fertilizer production in the ASEAN+5 region are shaped overwhelmingly by the relative cost of energy inputs. Because hydrogen generation accounts for 60–70% of the total cost of ammonia production, the price of coal versus imported LNG determines not only the competitiveness of domestic fertilizer industries but also the degree of exposure to global energy markets and geopolitical risk [29]. This section evaluates the comparative economics of coal-based versus LNG-based ammonia production, using $/GJ as the common metric, and examines the CO_2 emission intensity associated with each pathway.

Across the ASEAN+5 region, domestic coal prices are consistently lower and more stable than imported LNG. Typical historical averages include:

Fuel	Cost ($/GJ)	Notes
Domestic coal (China, India, Indonesia)	2-4	Stable, locally sourced, long-term contracts
Imported LNG (Japan, South Korea, ASEAN)	10-25	Highly volatile, exposed to global sport markets

Coal's cost advantage is structural. China, India, and Indonesia collectively hold some of the world's largest coal reserves, enabling long-term supply contracts insulated from global price shocks [30]. By contrast, LNG prices in Japan, South Korea, and Southeast Asia are tied to the Japan Korea Marker (JKM), which has experienced extreme volatility, rising from $4/GJ in 2019 to over $50/GJ during the 2022 global energy crisis [31]. This volatility directly impacts fertilizer producers, as SMR-based hydrogen production becomes uneconomic when LNG exceeds $10–12/GJ [32].

Hydrogen production costs reflect the underlying energy price differential. Coal gasification in China and India typically produces hydrogen at:

$0.90–1.46/KG H_2 FOR COAL GASIFICATION [33]

By contrast, SMR using imported LNG ranges from:

$1.50–3.00/KG H_2, DEPENDING ON LNG PRICE AND PLANT EFFICIENCY [34]

During periods of LNG price spikes, SMR-based hydrogen can exceed $4.00/kg, rendering LNG-based ammonia production uncompetitive relative to both coal-based domestic production and imported urea [35].

Coal gasification plants require higher capital expenditure (CAPEX) due to the complexity of gasifiers, air separation units, and syngas cleanup systems. Typical CAPEX values include:

- Coal-based ammonia plant: $1,500–2,200 per tonne of annual capacity

- LNG-based ammonia plant: $900–1,300 per tonne of annual capacity [36]

However, operating expenditures (OPEX) tell a different story:

- Coal-based plants benefit from lower and more stable domestic coal prices
- LNG-based plants face high and more volatile feedstock costs
- Coal-based plants often integrate heat recovery, reducing net energy costs

In India, for example, the Talcher coal-to-urea plant demonstrates that despite higher CAPEX, coal-based ammonia production can achieve lower long-term OPEX when LNG prices exceed $10/GJ [37].

Economic modeling from China, India, and Indonesia consistently shows:

- Coal-based ammonia plants achieve higher margins when LNG exceeds $10/GJ
- LNG-based plants become unprofitable during price spikes
- Coal-based plants maintain positive NPV under a wider range of price scenarios

A study of Chinese coal-to-ammonia plants found that profitability remained robust even when coal prices rose by 20%, whereas LNG-based plants became loss-making when LNG exceeded $12/GJ [38]. Similarly, Indonesian feasibility studies show that domestic coal-to-urea projects outperform LNG-based alternatives under all but the lowest LNG price scenarios [39].

Coal gasification is more carbon-intensive than SMR. Typical emission intensities include:

COAL GASIFICATION: 19–22 KG CO_2/KG H_2

SMR (LNG): 9–12 KG CO_2/KG H_2 [40]

This translates into higher CO_2 emissions per tonne of ammonia:

Production Pathway	CO_2 Emissions (t CO_2/t NH_3)
Coal gasification	2.8-3.5
SMR (LNG)	1.6-2.2

However, several factors complicate the narrative:

Coal-based plants often integrate CO_2 capture for urea synthesis, reducing net emissions per tonne of urea [41].

LNG supply chains include upstream methane leakage, which can significantly increase lifecycle emissions [42].

Coal-rich nations prioritize energy security over marginal CO_2 differences, especially when fertilizer supply is at stake [43].

6. STRATEGIC IMPLICATIONS FOR ASEAN+5

The economic and carbon profiles of coal versus LNG based fertilizer production have profound implications for the ASEAN+5 region:

- **China**: Coal based ammonia remains the lowest-cost option; LNG is used sparingly.
- **India**: Coal-to-urea is expanding to reduce LNG import dependence.
- **Indonesia**: Coal-based fertilizer production is central to national energy strategy.
- **Japan & South Korea**: LNG dependence creates vulnerability; both nations are exploring long-term coal-to-ammonia imports from Indonesia and Australia [44].

For coal-rich nations, the economic logic is clear: coal-based fertilizer production offers lower cost, greater price stability, and enhanced national security. For LNG-dependent nations, the challenge is balancing energy security with decarbonization goals.

Electrolytic hydrogen remains uneconomic for fertilizer production for the following reasons:

- EROEI < 1 for intermittent renewable-powered electrolysis
- High capital costs for electrolyzers
- Need for overbuilt renewable capacity
- Storage and buffering requirements
- High electricity prices in Japan, South Korea, and ASEAN [45]

Even optimistic projections place electrolytic hydrogen at $4–6/kg H_2 by 2030still far above coal or LNG pathways [46]. As a result, electrolytic hydrogen is fundamentally inflationary when used for fertilizer production, raising food prices and undermining food security [47].

7.0 GEOPOLITICS AND ENERGY–FOOD SECURITY

The post-2020 world has revealed the fragility of global supply chains and the degree to which modern economies depend on uninterrupted maritime trade. For the ASEAN+5 nations, ASEAN, China, India, Japan, and South Korea, this vulnerability is especially acute because their energy systems, fertilizer production, and food security are deeply intertwined with global shipping routes. The COVID-19 pandemic, the Russia–Ukraine conflict, Houthi attacks in the Red Sea, and escalating tensions in the South China Sea have collectively demonstrated that the globalized energy system is far more brittle than previously assumed [48]. These disruptions have forced policymakers to confront a difficult truth: *energy security is food security*, and both depend on resilient, domestically anchored supply chains.

Four maritime chokepoints are central to the energy security of the ASEAN+5 region:

- The Red Sea and Bab el-Mandeb Strait
- The Strait of Hormuz
- The Strait of Malacca
- The South China Sea

Each of these chokepoints is exposed to geopolitical instability. The Red Sea has seen repeated disruptions from Houthi missile and drone attacks on commercial vessels, forcing LNG carriers to reroute around the Cape of Good Hope, adding weeks of transit time and sharply increasing freight costs [49]. The Strait of Hormuz has become even more volatile in 2026, with Iran conducting drone strikes on commercial tankers, attacking multiple vessels in a single day, effectively transforming the waterway into an active conflict zone. The Strait of Malacca, through which one-third of global trade passes, is vulnerable to piracy, naval confrontation, and blockades. The South China Sea is increasingly contested, with overlapping territorial claims and growing military presence from China, the United States, and regional navies [50].

For LNG-dependent nations such as Japan, South Korea, and Singapore, these chokepoints represent existential vulnerabilities. More than 90% of Japan’s LNG imports pass through the Strait of Malacca and the South China Sea, while South Korea relies on similar routes for nearly all its LNG supply [51]. Any disruption, whether from conflict, sanctions, or maritime insecurity, would immediately threaten industrial operations, electricity generation, and fertilizer production.

This vulnerability has led policymakers to question the assumptions of globalism. As U.S. Secretary of State Marco Rubio recently argued, the belief that global supply chains would remain permanently stable has become “dangerous naïvety” [52]. For the ASEAN+5 region, this critique is not theoretical, it is a lived reality.

Across the ASEAN+5 nations, public policy documents reveal a consistent pattern: governments are increasingly regulating LNG imports while incentivizing domestic coal consumption for strategic industries such as fertilizer production.

CHINA

China's National Energy Administration explicitly caps LNG imports for industrial feedstock, prioritizing domestic coal for ammonia and methanol production. The 14th Five-Year Plan emphasizes "energy self-reliance" and "strategic autonomy," with coal-to-chemicals identified as a national priority [53]. China's coal-to-ammonia sector is now the largest in the world, producing roughly 79% of ammonia from coal [54].

INDIA

India's energy security doctrine identifies LNG import dependence as a major strategic risk. The Ministry of Chemicals and Fertilizers has repeatedly emphasized the need to diversify away from LNG-based SMR toward coal gasification, citing the Talcher plant as a model for future expansion [55]. India's coal-to-urea strategy is explicitly framed as a food-security measure.

INDONESIA

Indonesia mandates domestic coal allocation for strategic industries under the Domestic Market Obligation (DMO) policy. Fertilizer producers receive priority access to low-cost coal, while LNG imports are discouraged through tariff structures and long-term coal supply contracts [56]. Indonesia's National Energy Policy identifies coal gasification as a pillar of industrial resilience.

JAPAN AND SOUTH KOREA

Japan and South Korea, lacking domestic coal reserves, are the most exposed to LNG volatility. Both nations have begun exploring long-term coal-to-ammonia import agreements with Indonesia and Australia as a hedge against LNG supply disruptions [57]. Japan's Strategic Energy Plan acknowledges that LNG dependence is a "critical vulnerability" in the event of maritime conflict [58].

The ASEAN+5 nations with the largest populations and coal reserves, China, India, and Indonesia, are also the most stringent in regulating LNG imports. This is not coincidental.

These nations face:

- Large agricultural sectors
- High fertilizer demand
- Rapid population growth
- Limited natural gas reserves
- High exposure to global LNG price volatility

For these countries, coal is not merely an energy source, it is a strategic asset. Coal-to-fertilizer production ensures:

- Stable domestic fertilizer supply
- Insulation from global LNG markets
- Protection against maritime disruptions
- Lower long-term production costs
- Greater national autonomy

In contrast, Japan and South Korea, coal-poor and LNG-dependent, must rely on external suppliers and maritime trade, making them structurally vulnerable to geopolitical shocks [59].

The Green Revolution made hydrocarbons the invisible backbone of global food systems.

Today:

- 50% of global food production depends on synthetic nitrogen fertilizers
- 80–90% of nitrogen fertilizer depends on hydrocarbon-derived hydrogen
- Coal-to-fertilizer is the frontline of national security in coal-rich Asian nations [60]

This relationship is not widely understood outside technical and policy circles. Yet it is central to the survival of billions. Without hydrocarbons, the Haber–Bosch process cannot operate at scale. Without Haber–Bosch, global food production collapses. And without stable fertilizer supply, the ASEAN+5 nations, home to more than 3.5 billion people, would face catastrophic food insecurity [61].

Coal-to-fertilizer production is increasingly viewed as a national-security infrastructure. For ASEAN+5 nations, it provides:

- Resilience against LNG price shocks
- Reduced exposure to maritime chokepoints
- Stable domestic fertilizer supply

- Support for rural economies
- Protection against geopolitical coercion [62]

China's coal-to-chemicals sector is explicitly framed as a bulwark against foreign energy dependence. India's coal-to-urea expansion is justified as a food-security imperative. Indonesia's coal gasification strategy is tied to national industrialization goals. Even Japan and South Korea, despite lacking coal, are exploring coal-derived ammonia imports as a hedge against LNG volatility [63].

The post-2020 geopolitical landscape marks a shift away from the assumptions of the 1990–2015 globalization era. Nations are increasingly prioritizing:

- Domestic energy resources
- Strategic autonomy
- Industrial resilience
- Food-system stability
- Reduced dependence on maritime trade

In this context, coal gasification is not an anachronism, it is a strategic adaptation to a world where global supply chains can no longer be taken for granted [64].

Fertilizer is not merely an agricultural input, it is a national-security asset. The ASEAN+5 nations recognize that:

Without fertilizer, crop yields collapse
Without stable hydrogen supply, fertilizer production collapses
Without hydrocarbons, hydrogen supply collapses

Thus, coal-to-fertilizer production is the final line of defense in ensuring food security for billions of people [65].

Coal remains central to the region's fertilizer strategy because it is:

Abundant
Cheap
Domestically controlled
Geopolitically insulated
Technically compatible with large-scale hydrogen production

For these reasons, coal gasification is not merely an industrial choice, it is a geopolitical necessity [66]. With the present conflict in the Persian Gulf and the closure of the Strait of

Hormuz, coal gasification over dependence on LNG imports, will undoubtedly gain greater public support in Asia, given over 80 % of LNG shipments through this choke-point are destined for Asian markets [67].

CONCLUSION

The Haber–Bosch process has indelibly reshaped human civilization, decoupling food production from the whims of natural nitrogen cycles and enabling the Green Revolution to sustain an eightfold population increase since 1900. Today, synthetic nitrogen fertilizers, rooted in hydrocarbon-derived hydrogen, nourish over half of humanity, underscoring hydrocarbons' role not merely as energy but as the chemical bedrock of modern agriculture and societal stability.

In the ASEAN+5 region (ASEAN nations plus China, India, Japan, and South Korea), this reality manifests starkly amid diverging resource endowments and geopolitical pressures. Coal-rich giants like China, India, and Indonesia increasingly prioritize coal gasification for ammonia and urea production, leveraging abundant domestic reserves to insulate against volatile LNG markets, maritime chokepoints (e.g., Strait of Hormuz, South China Sea), and supply disruptions from conflicts or sanctions. China's coal-to-chemicals dominance, India's expanding coal-to-urea initiatives (e.g., Talcher), and Indonesia's strategic coal allocation policies exemplify this shift toward energy sovereignty, cost stability, and food security. Even LNG-dependent Japan and South Korea explore coal-derived ammonia imports as hedges against global volatility.

Despite higher CO_2 intensity, coal pathways offer structural advantages: lower feedstock costs ($2–4/GJ vs. $10–25/GJ for LNG), robust profitability under price shocks, and integration with urea synthesis that captures CO_2. Electrolytic "green" hydrogen remains uneconomic (EROEI <1, high overbuild needs), rendering it inflationary for fertilizer and unsuitable without massive subsidies. As post-2020 geopolitics exposes global supply-chain fragility, exacerbated by Red Sea disruptions, Hormuz conflict, and Indo-Pacific tensions, ASEAN+5 nations increasingly view coal gasification as national-security infrastructure. Prioritizing domestic resources over import reliance safeguards rural economies, agricultural yields, and billions of livelihoods. In an era of brittle globalization, coal-to-fertilizer production is no relic but a pragmatic adaptation: resilient, affordable, and geopolitically insulated. The path forward demands balancing this strategic imperative with emissions management, yet the physics and economics affirm hydrocarbons' enduring centrality to feeding Asia's masses.

Endnotes

1. *Joseph Fournier, "From Guano to Green Revolution: How the Haber–Bosch Process Fueled Urbanization and Transformed Global Agriculture," Big Media, 2024.*
2. *Vaclav Smil, Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production (Cambridge, MA: MIT Press, 2001).*
3. *Erisman, Jan Willem, et al. "How a Century of Ammonia Synthesis Changed the World." Nature Geoscience 1, no. 10 (2008): 636–639.*
4. *Bhandari, Rajesh, et al. "Energy Return on Investment (EROI) of Hydrogen Production." International Journal of Hydrogen Energy 46, no. 5 (2021): 3583–3595.*
5. *Higman, Christopher, and Maarten van der Burgt. Gasification, 2nd ed. (Burlington, MA: Gulf Professional Publishing, 2008).*
6. *International Energy Agency (IEA). Southeast Asia Energy Outlook 2022. Paris: IEA, 2022.*
7. *Smil, Enriching the Earth.*
8. *Ibid.*
9. *Appl, Max. "Ammonia." In Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, 2011.*
10. *Ibid.*
11. *Le Châtelier, Henry. "On Chemical Equilibrium." Annales des Mines 13 (1888): 157–180.*
12. *Appl, "Ammonia."*
13. *Ibid.*
14. *Smil, Enriching the Earth.*
15. *IEA, Southeast Asia Energy Outlook 2022.*
16. *Higman and van der Burgt, Gasification.*
17. *Xu, Guohua, et al. "Coal Consumption in Ammonia Production." Energy Policy 112 (2018): 1–12.*
18. *Chen, Yufeng, et al. "China's Coal-to-Chemicals Industry." Energy Economics 95 (2021): 105–123.*
19. *Government of India, Ministry of Chemicals and Fertilizers. Talcher Fertilizer Project Brief, 2023.*
20. *Indonesian Ministry of Energy and Mineral Resources. National Energy Policy (RUEN), 2020.*
21. *IEA, Japan 2021 Energy Policy Review.*
22. *Vietnamese Ministry of Industry and Trade. National Energy Master Plan, 2021.*
23. *FAO. World Fertilizer Trends and Outlook to 2050. Rome: FAO, 2022.*
24. *Chen et al., "China's Coal-to-Chemicals Industry."*

25. *Ibid.*

26. *IEA, Southeast Asia Energy Outlook 2022.*

27. *Oilprice.com. . "China's Renewable Boom Masks a Quiet Coal-to-Liquids Expansion," 2023.*

28. *Indonesian Ministry of Energy, RUEN.*

29. *Appl, "Ammonia."*

30. *IEA, Coal 2023: Analysis and Forecast to 2026.*

31. *Platts. Japan Korea Marker (JKM) LNG Price Assessments, 2019–2023.*

32. *IEA, Gas Market Report 2023.*

33. *Chen et al., "China's Coal-to-Chemicals Industry."*

34. *IEA, Hydrogen: Tracking Report 2023.*

35. *Ibid.*

36. *Appl, "Ammonia."*

37. *Government of India, Talcher Fertilizer Project Brief.*

38. *Chen et al., "China's Coal-to-Chemicals Industry."*

39. *Indonesian Ministry of Energy, RUEN.*

40. *IEA, Hydrogen: Tracking Report 2023.*

41. *Appl, "Ammonia."*

42. *Alvarez, Ramón A., et al. "Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain." Science 361, no. 6398 (2018): 186–188.*

43. *IEA, Southeast Asia Energy Outlook 2022.*

44. *Japanese Ministry of Economy, Trade and Industry (METI). Strategic Energy Plan, 2021.*

45. *Bhandari et al., "Energy Return on Investment (EROI) of Hydrogen Production."*

46. *IEA, Hydrogen: Tracking Report 2023.*

47. *FAO, World Fertilizer Trends and Outlook to 2050.*

48. *UNCTAD. Review of Maritime Transport 2023.*

49. *Lloyd's List Intelligence. Red Sea Shipping Disruption Report, 2024.*

50. *CSIS Asia Maritime Transparency Initiative. South China Sea Military Developments, 2023.*

51. *METI, Strategic Energy Plan.*

52. *U.S. Department of State. Remarks by Secretary Marco Rubio on Global Supply Chain Security, 2024.*

53. *National Energy Administration of China. 14th Five-Year Energy Plan, 2021.*

54. *Chen et al., "China's Coal-to-Chemicals Industry."*

55. *Government of India, Ministry of Chemicals and Fertilizers. National Fertilizer Policy Review, 2022.*
56. *Indonesian Ministry of Energy, RUEN.*
57. *METI, Strategic Energy Plan.*
58. *Ibid.*
59. *IEA, Japan 2021 Energy Policy Review.*
60. *Smil, Enriching the Earth.*
61. *FAO, World Fertilizer Trends and Outlook to 2050.*
62. *IEA, Southeast Asia Energy Outlook 2022.*
63. *METI, Strategic Energy Plan.*
64. *UNCTAD, Review of Maritime Transport 2023.*
65. *Smil, Enriching the Earth.*
66. *IEA, Coal 2023: Analysis and Forecast to 2026.*
67. *EIA, About one fifth of global LNG trade flows through the Strait of Hormuz, 2025.*