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Evaluating Green Ammonia Adoption in Indian Fertilizer Industry

Ammonia is the key intermediate for deriving nitrogen in fertilizers. India produced 19.5 million tonnes (million MT) ammonia during 2023-24. Of which almost 92% was used for production of 31.5 million MT urea and rest for producing nitric acid and complex fertilizer plants. Urea plants are integrated with ammonia plants as the second raw material for production of urea *i.e.* carbon dioxide (CO_2) is generated in situ in ammonia plant. India imported about 2.2 million MT of ammonia for the production of DAP and NP/NPK complex fertilizers during 2023-24. Fertilizer Industry has been identified as one of the prominent sectors for consuming renewable energy, green hydrogen and green ammonia. It is a fact that fertilizer is the largest consumer of ammonia which is the basic raw material for production of nitrogen-based fertilizers. However, there is a need to understand the way different fertilizers are produced and how these green resources can be utilized in an effective manner.

Ammonia and phosphoric acid are combined to produce ammonium phosphate *i.e.* NP grade fertilizers and potash (K) is added for production of various grades of NPK fertilizers. In this process, ammonia is directly used and grey ammonia can be substituted with green ammonia. To kick start, 0.739 million MT per annum of green ammonia will be procured by 14 complex fertilizer plants in the first trench which is about 25% of total ammonia requirement. The agreement for procurement of green ammonia will be for a period of 10 years. There will be commercial challenge with respect to viability of fertilizer production as the cost of green ammonia may be 2½ times higher than grey ammonia. The Ministry of New and Renewable Energy is incentivizing production of green ammonia for three years. However, the incentive may not be enough to cover the gap between grey and green ammonia prices and would require further support to make procurement viable. The supply of green ammonia will commence 36 months after Green Ammonia Purchase Agreement. Experience of the first trench will help to build confidence among both suppliers and users of green ammonia for extending period and offtake. Further, government can moderate policies for future de-carbonization.

Blending of green ammonia with existing grey ammonia has been suggested. However, this will pose limitation in existing urea plants as they have already debottlenecked their capacity by 20-50%. There is surplus ammonia generation in the existing plants due to lean gas and facing shortage of CO_2 for production of urea. Blending of green ammonia will necessitate reduction of load in the upstream ammonia plant to balance CO_2 production. This will affect efficiency of ammonia plant due to its operation on partial load. Installation of carbon dioxide recovery (CDR) plants from flue gases may be an option but it is capital intensive and additional energy will have to be spent in its operation.

More challenging preposition is to utilize green hydrogen in ammonia production. In natural gas steam reforming (SMR) process, hydrogen is generated as a product. Presence of hydrogen in the natural gas as feed would affect the forward reaction in SMR. This may result in lower conversion of natural gas into products and inefficient operation of primary reformer. Since process steps of gas purification (sulphur removal), primary reformer, secondary reformer, HT Shift and LT Shift are highly integrated, it may affect the entire plant efficiency. One of the studies pointed out that hydrogen can be used as feedstock by blending with natural gas upto 2% only.

Utilization of hydrogen in the synthesis loop will be limited by the ammonia reactor space velocity. The introduction of hydrogen in synthesis loop may result in lowering the production in the front end through conventional route from natural gas. This will result in lower CO_2 generation thus limiting urea production. Production of one MT of urea requires about 740 kg of carbon dioxide which is not generated during electrolysis of water for generation of hydrogen. An air separation unit is required for generation of nitrogen. Urea plants based on green ammonia will have to find another suitable source of CO_2, which needs to cleaned and

Utilization of green ammonia in complex fertilizer plants may commence in mid-term. However, utilization of green hydrogen and ammonia in urea plants requires techno-feasibility study.

transported. This will require huge investment thus potentially increasing cost of production of urea. Further, storage will be needed at both generation and user sites. Production of urea is a continuous process, and any disruption in supply of CO_2 from external source will also affect the operation of the plant. Commissioning a new green ammonia plant in the vicinity of CO_2 generating site may also be explored.

Green hydrogen would pose challenges as a fuel in ammonia plant. On volumetric basis, hydrogen is one third less energy dense than methane (natural gas). This means three times more volume flow of hydrogen has to be maintained to provide the same heat (energy) input as methane (natural gas). Further, handling of these larger volume flows, systems such as gas turbines and burners need to be designed to withstand the higher amount of hydrogen firing. There is likelihood of high temperature hydrogen attack. Utilization of green hydrogen as fuel in the existing gas turbine / heat recovery unit is not possible. As per a study, the existing gas turbines can take only 1% hydrogen as intake. As the volume of hydrogen is significantly higher than that of natural gas, use of green hydrogen shall lead to capacity limitation in equipment, pipelines and production of the plant. Thus, use of green hydrogen will require complete replacement or major modifications of these equipment as they are not designed for the hydrogen fuel. It shall require huge capex investment and timeframe.

Hydrogen gas is highly flammable and can easily ignite, thus leading to potential accidents and explosions. Additionally, hydrogen transportation involves use of high-pressure containers and pipelines, which can pose safety risks. As hydrogen is a very light and small element, it permeates the metal. The leakage from high pressure can easily occur, in addition to the problem related to hydrogen embrittlement. Thus, utilization of green hydrogen in existing plants will require a study of safety hazards and metallurgy of the plant and equipment for its compatibility with green hydrogen.

The National Green Hydrogen Mission specifies replacing the imported grey ammonia with domestic green ammonia by 2034-2035. A large number of project proponents have shown interest in installing green ammonia plants. However, majority of ammonia is for export. Policy of the Government of India is also to increase the share of natural gas in energy mix from current 6% to 15% by 2030. Fertilizer industry share is almost one third of natural gas consumption in the country. To meet the growing need of the food, fiber, fuel and feed of the burgeoning population, there will be an increased requirement of fertilizers in the country. It is estimated that by 2040, there will requirement of about 44 million MT of urea and 33 million MT of DAP and complex fertilizers. Utilization of green hydrogen and ammonia in existing urea plants as feed or fuel needs detailed technical and economic feasibility study which may take a few years. Till such time, use of cleaner fuels like natural gas to be continued for production of urea and green ammonia can be used for producing non-urea fertilizer products.

Other than technical challenges, there are economic challenges associated with renewable energy and green hydrogen. Green hydrogen is currently more expensive to produce than its grey counterpart derived from natural gas. This higher cost translates to costly green ammonia and hence urea. Further, there will be an additional cost for arranging CO_2 supply. This will make production of urea from green ammonia less competitive with traditionally produced ammonia. Fertilizers are essential nutrients for growth of agricultural productivity. Higher cost of inputs may translate to higher food inflation. Fertilizer industry operates under a controlled policy environment where the MRP of the urea is fixed by the government and industry is not having mandate to pass the increased cost to the end users *i.e.* farmers. Any increase in cost of production would lead to increase in subsidy burden of the government. The utilization of green ammonia in urea industry will pave its way as technology gets matured, and it becomes viable coupled with conducive government policies. ■