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Fertilizer Manufacturing in Malawi

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“ The domestic production of both inorganic and organic fertilizers will result in reduced cost of fertilizers, increased job creation, increased participation of local Malawians at all fertilizer value chain, reduced imports and increased exports leading to increased foreign exchange earnings. ”

- Malawi National Fertilizer Policy (2021)

This paper aims to describe the fertilizer manufacturing process in detail and present the opportunities that manufacturing fertilizer in Malawi offers as a source of economic growth and sustainable food security in Malawi.

The Malawi Context

The Agricultural Sector

Malawi’s population is growing at a rate of 2.6 % per annum[1]. To meet increasing food demand, agricultural production needs to grow, but to achieve that without converting additional forest land to cropping, an increased utilization of agricultural inputs is needed. Inorganic fertilizer is a critical input needed to meet this growing demand[2]. Although it is not the only input, the low use of fertilizer is a major impediment to increased agricultural productivity and thereore farm incomes in Africa. More specifically, the limited use of the correct fertilizer (e.g. right type & right rate) is a key constraint in agricultural production in Malawi. For many years, Malawian farmers have used low levels of fertilizers (both organic and inorganic). This has led to low levels of farm productivity, resulting in low farm incomes, food insecurity and malnutrition. Although a significant share of farmers has had access to fertilizers in the past through various national input subsidy programs, the country, as a whole still applies suboptimal levels of fertilizers.

A distinctive feature that characterizes smallholder farming systems in much of Sub-Saharan Africa (SSA) is the wide diversity of farming households and marked heterogeneity in both socio-economic factors and physical factors such as soil fertility[3].

[1] World Bank (2020) – World Bank Databank
[2] AFDB 2020 – African Fertilizer Financing Mechanism
[3] Tittonell et al 2010 - The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa – A typology of smallholder farms

This means that input supply systems, particularly those for fertilizer, must be agile enough to respond to varying farmer crop and field nutrient requirements. The availability of crop and field specific fertilizer will require the fertilizer sector as a whole to become more agile and demand-driven. A key factor in facilitating a comprehensive and agile fertilizer market is to have in place enabling government policy and to increase local fertilizer manufacturing.

Malawi Fertilizer Market

For the past five years, the annual fertilizer market in Malawi is between 350,000-370,000 MT in total. With the new agricultural subsidy program known as the Affordable Inputs Program (AIP), this figure has increased significantly in the past year to 400,000 – 450,000 MT. In the 2020-21 growing season, 345,710 MT of fertilizer were sold under the AIP program reaching 3,457,000 beneficiaries[4].

There are about 15 major industry players in the fertilizer market in Malawi and some ⅓ of these players have some form of integrated retail network[5]. Annual fertilizer sales are made by these players are made to both commercial and smallholder farmers. The key contrast between these two market segments is the level of customization of the fertilizer requirements. Customers within the commercial or estate sector have the economies of scale and the technical expertise to demand and access customized formulations based on the results of their soil analysis and crop requirements. Smallholders, however, are limited to what is readily accessible on the local market. Given the marked variation of agro-ecological conditions across Malawi, smallholders and therefore, the larger agricultural economy could greatly benefit from access to fertilizer which addresses these variations.

Malawi's fertilizer consumption is currently centered mostly around 2 major crops: maize and tobacco. The average fertilizer recommendation for the production of maize by smallholder farmers is approximately 200kg per hectare which yields between 3 - 5 MT of maize per hectare. In reality the average smallholder farmer is estimated to use on average approximately 43kg per hectare and yields 1.5MT of maize per hectare[6]. In contrast, the average fertilizer consumption for the production of maize in commercial farming is approximately 400kg per hectare which yields between 5 - 10 MT of maize per hectare.

[4]Fertilizer Association of Malawi (2021) – Affordable Inputs Program (AIP) 2020-21 Report
[5]Based on 2020 membership in the Fertilizer Association of Malawi (FAM)
[6]Optimizing Fertilizer Use within the Context of Integrated Soil Fertility Management in Malawi

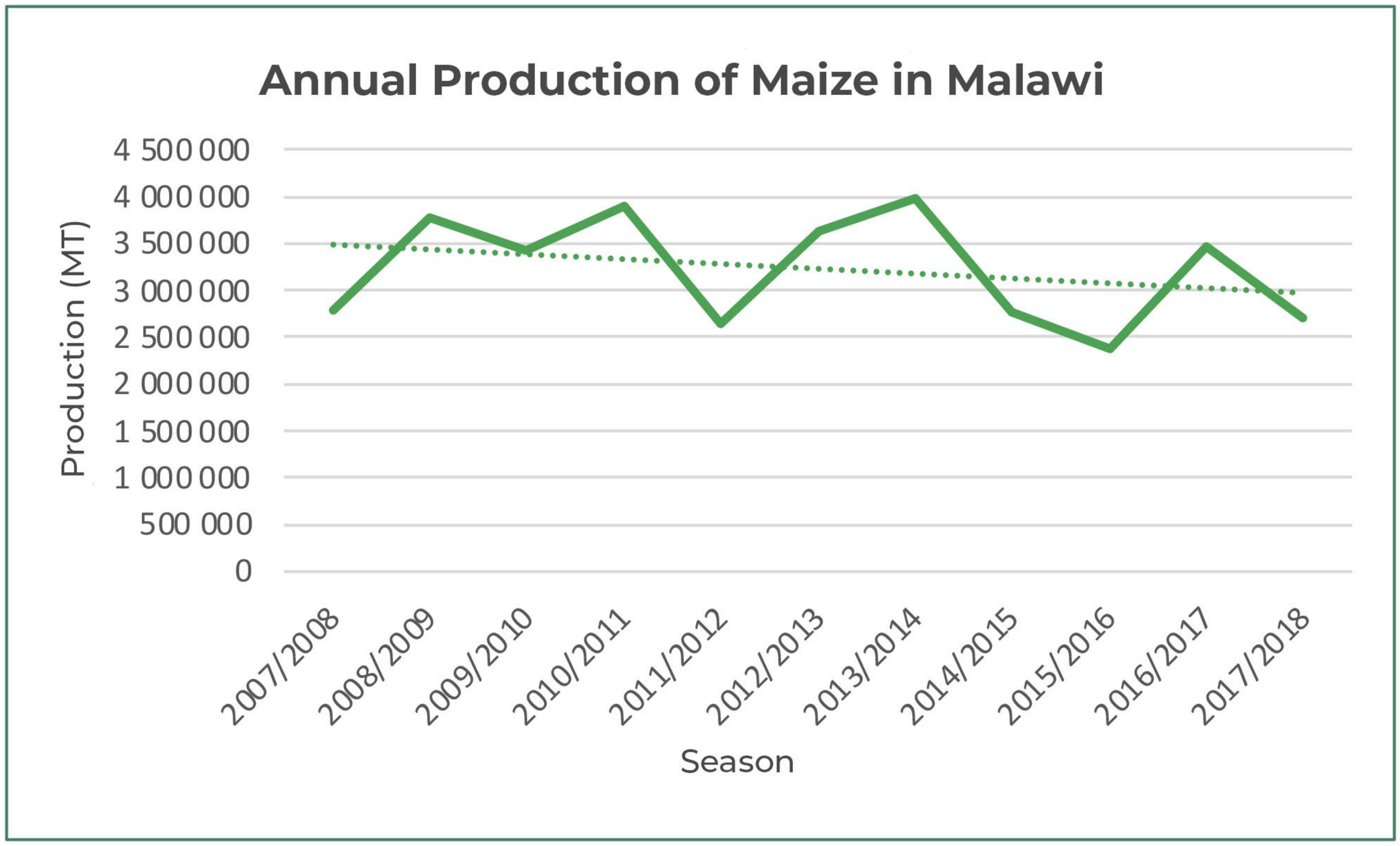

Figure 1: Annual Production of Maize in Malawi (Min Ag APES)

Figure 1 above illustrates the annual production of maize in Malawi between 2008 and 2018. Although the total hectares under maize production has stayed roughly the same over time at 1.6 million hectares, total production has declined slightly meaning that yield (kgs/ha) is declining overall. This further illustrates the critical need for tailored fertilizer products and increased quantity and timely application, to help increase the efficiency of fertilizer use and yield outcomes.

Due to the dominance of maize as Malawi's main food crop and the introduction of the Government subsidy program which specifically caters to maize production, other crops such as legumes, rice, sweet potatoes, and cassava receive very little and often no fertilizer. This presents a very significant gap for crop specific fertilizers that could increase the yields of these crops substantially thereby providing an additional income opportunity for smallholder farmers. The production of crop specific fertilizers would be best suited to the "blending" manufacturing process which is locally achievable.

Fertilizer Manufacturing

Process Overview

The process of manufacturing fertilizer is a lengthy and complex process requiring specific types of natural resources and sophisticated manufacturing facilities.

Figure 2 below illustrates the most common processes of producing the three main fertilizer components – Nitrogen, Phosphorus, and Potassium.

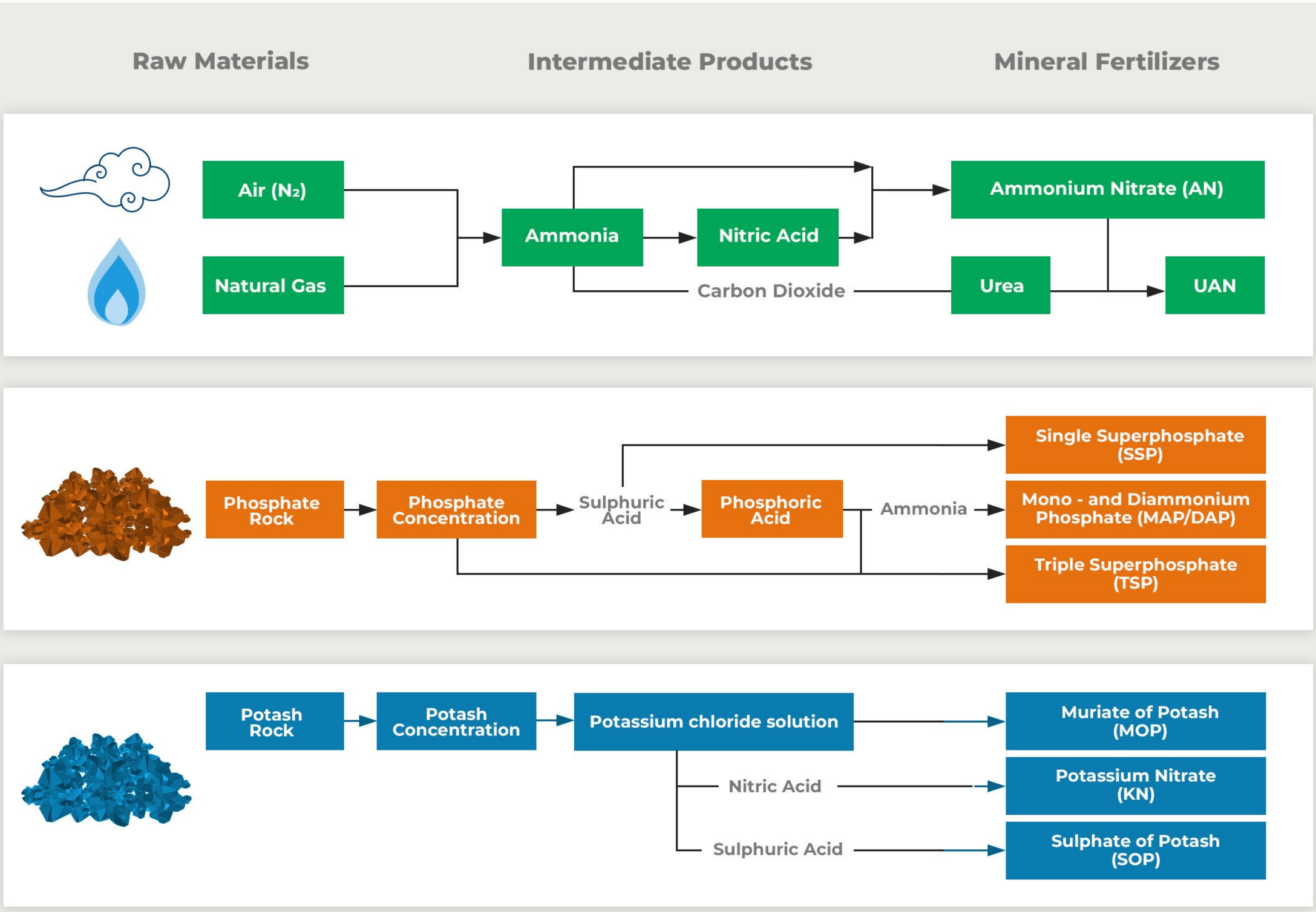

Figure 2: Fertilizer Production (Fertilizer Europe)

Each of the three major components of fertilizer undergo a specific process to be made into an accessible form which can be readily taken up by the crop:

- **Nitrogen (N)** – Nitrogen is the primary nutrient in inorganic fertilizers, accounting for 57% of total fertilizer consumption globally. Nitrogen is critical to protein development and is the engine behind crop's ability to take up and process nutrients. The majority of nitrogen fertilizers are urea based (46% N). Roughly 43% of the world production of urea is located in China. Other major urea manufacturers and suppliers to the global market are India (13.5%) and countries of the Middle East Region, such as Qatar, Saudi Arabia, Iran and Oman (about 13%)[7]. In the next 5-10 years there is a possibility that nitrogen could be produced in northern Mozambique from natural gas. Having a closer source of nitrogen would reduce logistics costs of importing it from overseas. Malawi does not have any nitrogen stores, or natural gas or a cheap source of energy with which it could use to capture Nitrogen, therefore, this needs to be imported from beyond its borders.

[7] YARA (2018) - Fertilizer Industry Handbook

There are 3 methods that can be used to produce Nitrogen:

- ***Haber-Bosch process:*** This process involves synthesizing anhydrous liquid ammonia from hydrogen from natural gas and atmospheric nitrogen from air as shown in Figure 2 above.
- ***Fractional Distillation:*** In simple terms, a four-step process is used. It begins with cooling the air, then isolate the nitrogen, separate it from the air, and then finally collect it. At the correct low temperature, the nitrogen becomes liquid and can then be extracted and harvested for industrial processes. These steps are illustrated in **Figure 3** below.

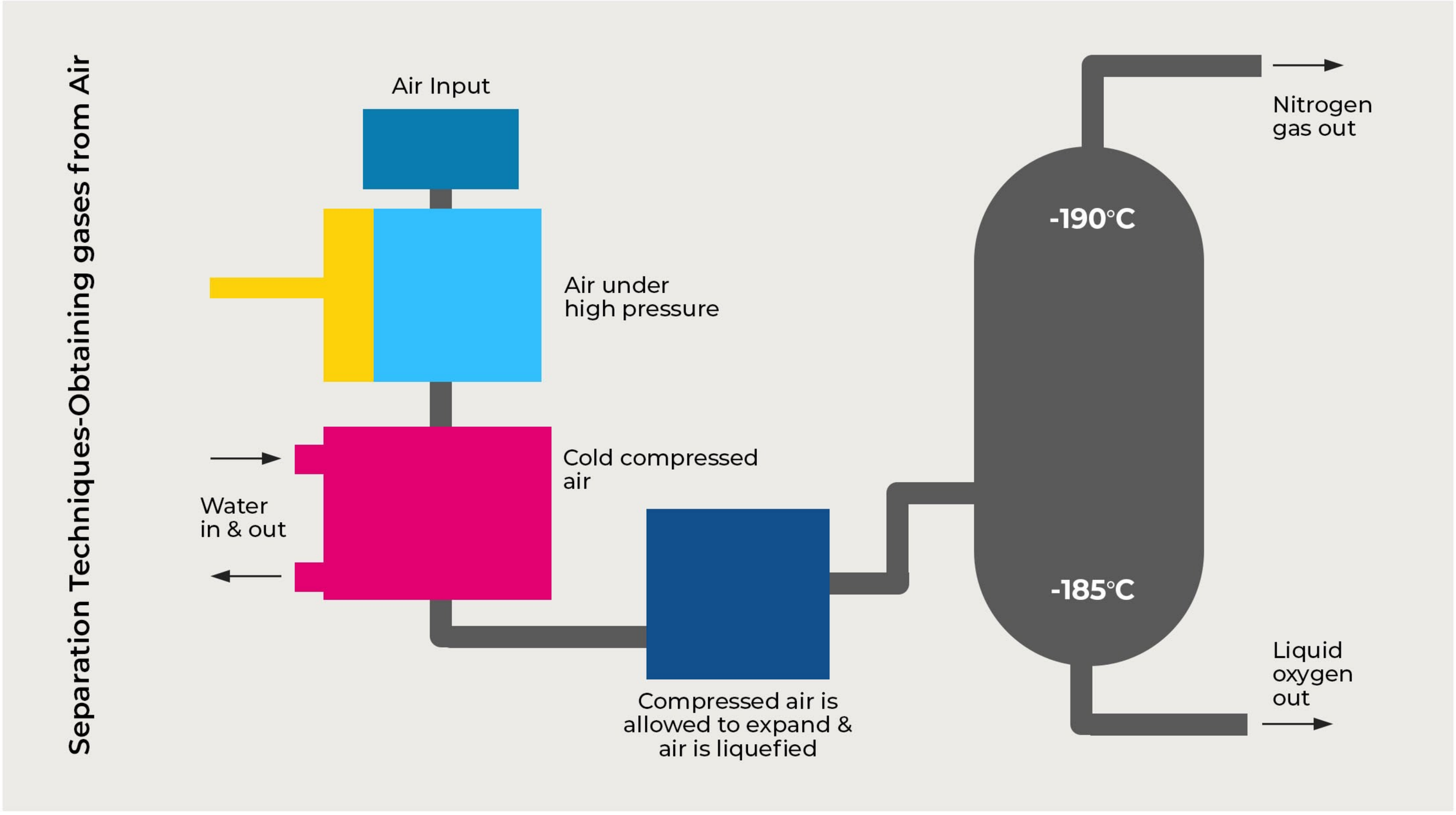

Figure 3: Fractional Distillation (byjus.com)

This process requires a lot of low cost energy from natural gas, coal or hydropower.

- ***Green Ammonia:***

Green ammonia[8] is a more sustainable and environmentally friendly way of producing nitrogen fertilizer. Conventional ammonia is typically produced using natural gas as feedstock and produces carbon dioxide as a byproduct.

Alternatively, green ammonia is produced by using solar/wind/hydropower to produce electricity that then feeds an electrolyzer to extract hydrogen from water, while nitrogen is separated from air using an air separation unit. As solar technology becomes more efficient and cheaper, this presents a future opportunity for fertilizer manufacturing in Malawi. **Figure 4** below illustrates the process of creating green ammonia.

[8] Green Ammonia: Carbon-Neutral Fertilizer Production - YARA 2021.

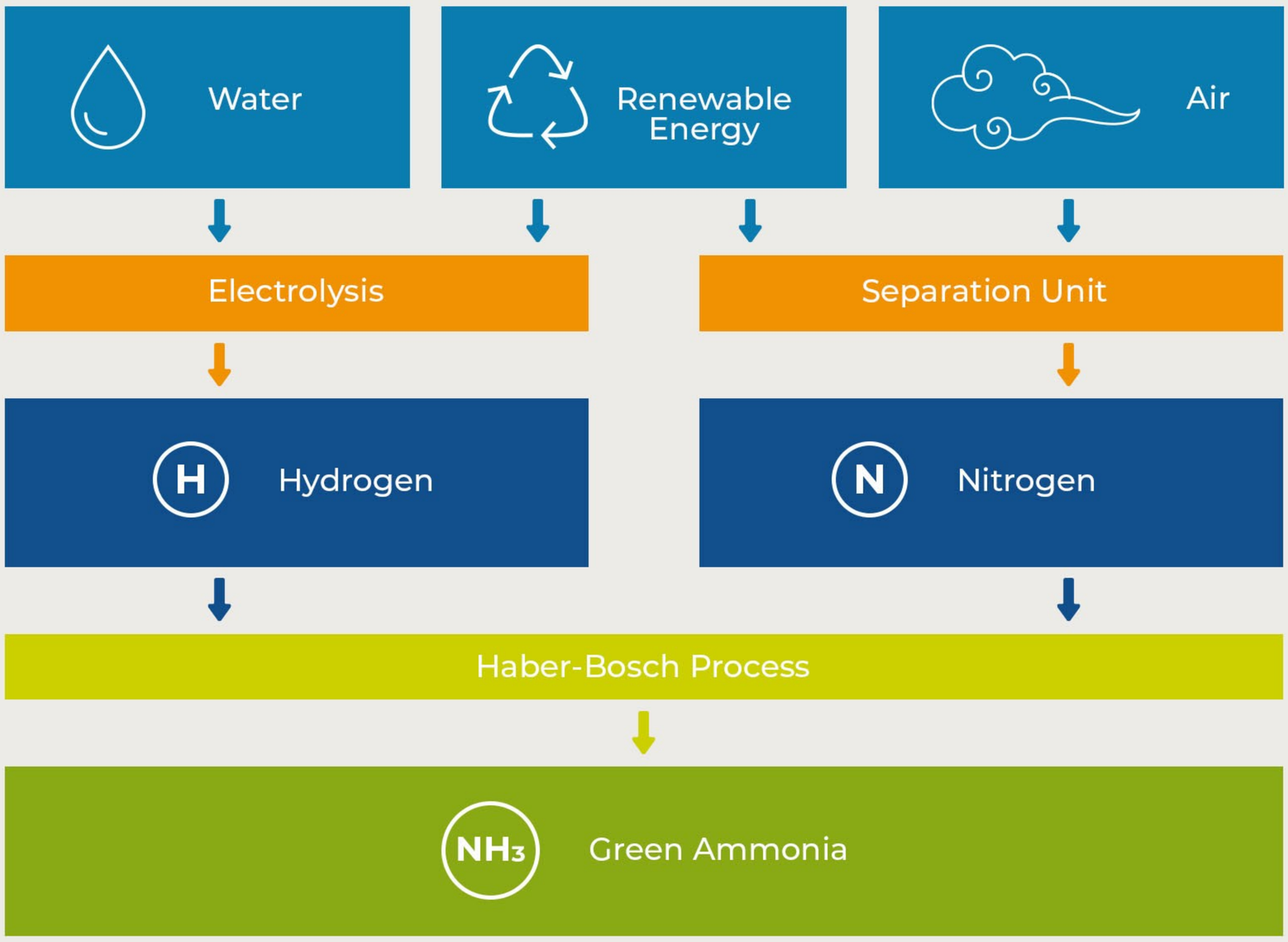

Figure 4: Green Ammonia Process (Fertilizer Europe)

- **Phosphate (P)** - Phosphate is the second key nutrient of fertilizer. It helps early root development and strengthens the plants' ability to resist disease and plays an important role in increasing crop yields and overall quality. There is a small phosphate rock mine Thundulu in the Southern Region of Malawi, but the available phosphate rock is not of a high enough quality to be incorporated directly into fertilizer. Phosphate in rock needs to be concentrated or "beneficiated" before being added into a fertilizer. When phosphate rock is brought out of the ground it is naturally mixed with unwanted material called gangue. Gangue is separated from the phosphate ore through the process of beneficiation which includes screening at varying size fractions, washing and flotation. Due to this intensity of this process, it is only commercially viable when the rock phosphate is of a high phosphate content to begin with, typically over 16%. Thundulu rock phosphate only contains +/- 8%. As a result, it is more cost efficient to purchase phosphate concentrates in the form of DAP and MAP made from rich phosphate rock sources elsewhere in the world.

- **Potassium (K)** - **Potassium** is the third key nutrient of **fertilizers**. It helps strengthen plants' abilities to resist disease and plays an important role in increasing crop yields and overall fruit quality. Potassium also assists with water regulation in plants and is very important for drought resistance. Potash deposits occur as beds of solid salts beneath the earth's surface and brines in dying lakes and seas.

Elemental potassium (K) is not found in a pure state in nature because of its high reactivity. It can be purified but must be kept in oil to retain its purity and prevent violent reactivity. The world's largest stocks of potassium materials are in Canada and China.

Table 1 summarizes the key sources of Malawi's fertilizer elements for the short, to medium and long term.

Element	Source	0-5 Years	5-10 Years	10-20 Years
Nitrogen	Made using the Haber-Bosch process which combines hydrogen from natural gas with nitrogen to make ammonia (NH3).	Not available from Malawi. However, with Government support and investment, it could be locally produced via the 'green ammonia' process using solar energy and sustainable fuel source of hydrogen, e.g. water, to produce ammonia in a sustainable and car-bon-neutral way.	Plans are underway for it to be produced from natural gas in northern Mozambique and it could then be imported at a lower cost than when it's imported from overseas.	Malawi could be producing enough for local demand through the Green Ammonia process and where production capacity exceeds demand, could become an exporter of Nitrogen.
Phosphorus	Obtained by mining phosphate rock.	Yes, low grade phosphate rock from Thundulu mine in Southern Malawi.		
Potassium	Mined from salt mines.	No, will have to continue to be imported.		
Sulfur	Can be mined or recovered from oil and gas production.	No, will have to continue to be imported.		

Table 1: Sources of Fertilizer Raw Materials in Malawi

Table 2 below shows the countries that are the largest producers of each of the fertilizer raw materials globally.

Element	Nitrogen	Phosphorus	Potassium	Sulfur
Countries	1. China 2. India 3. United States 4. Russia 5. Canada 6. Indonesia 7. Qatar 8. Pakistan 9. Egypt 10. Saudi Arabia	1. China 2. Morocco & Western Sahara 3. United States 4. Russia 5. Jordan 6. Saudi Arabia 7. Brazil 8. Egypt 9. Vietnam 10. Peru/Tunisia	1. Canada 2. Russia 3. Belarus 4. China 5. Germany 6. Israel 7. Jordan 8. Chile 9. Spain	1. United Arab Emirates 2. Russia 3. Qatar 4. Canada 5. Kazakhstan 6. United States 7. Iran 8. Germany 9. Japan

Table 2: Global sources of Fertilizer Raw Materials (Feeco International)

Current Capacity of Malawian Fertilizer Producers

Currently, the fertilizer industry in the country is not fully developed as most of the fertilizer companies import fertilizers and are not directly involved in production. Given the constraints listed above, there are only two fertilizer production processes that are feasible in Malawi – steam granulation and bulk blending. Currently, there are two major companies that produce fertilizer using these two processes in Malawi – Optichem and Malawi Fertilizer Company (MFC). Optichem uses a process called steam granulation to create compound fertilizers. It essentially involves the "wet massing" of small powder particles using steam as granulation fluid instead of traditional liquid, water. In this manufacturing technique, agglomeration of powder particles is facilitated by injecting a jet of steam into the bed of fluidized particles to be granulated[9]. This process creates compounds with the same amount of nutrients in each granule. Annually, Optichem produces about 20,000 MT using the steam granulation process. Optichem is able to granulate key nutrients such as phosphate, potassium and nitrogen and combine them with additional raw material (Dolomitic lime, Calcitic lime, rock phosphate and Clay) from Malawian sources. This product can be a full fertilizer compound formulation or a low nutrient fertilizer formulation used as a raw material in fertilizer blending. It forms a significant component used by MFC to add to other high nutrient ingredients such as DAP, MOP and Urea imported for the manufacture of fertilizer.

Optichem and the recently upgraded Malawi Fertilizer Company (MFC) blending plant in Liwonde also use a process called "Bulk Blending". Below is an illustrative example of how blending works.

In **Figure 5** below, we have taken a relevant example of the government recommended maize basal dressing:

Optichem low nutrient fertilizer Malawi 228kg	**= 1 MT of NPK 23:10:5 + 6S + 1Zn** 22.8% LOCAL RAW MATERIAL + BAGS + BLENDING **33% MALAWIAN CONTENT** **22.8% OF 150,000 MT = 34,200 MT** **34,200 MT x US$ 480 = US $16.4 MILLION** **THIS REPRESENTS US$ 16.4 MILLION IMPORT SUBSTITUTION AND FOREX SAVING.**
DAP Saudi Arabia 217kg	
MOP Jordan 83kg	
UREA Arabian Gulf 405kg	
B90 + Zinc Sulphate +Sulphur Various nutrients 63kg	

Figure 5: Illustrative example of blending components

[9] Fertiplant Engineering India - NPK granulation process.

Blending technology is considered very appropriate where between approximately between 25-40% of a finished product could be sourced from raw materials found in Malawi. The concept of fertilizer blending was developed in order to achieve three main objectives:

1. To allow the incorporation of local content at point of consumption, thereby substituting imports
2. To reduce the transport volumes and costs of importing fully finished product by importing concentrates only.
3. To allow for the blending of "Custom fertilizer formulation" fertilizers closer to where they are be required, for large and small users alike, meeting farmer needs depending on local crop and soil requirements.
4. To reduce the cost of fertilizer to the end consumer, the smallholder farmer, and increase agricultural productivity.

Benefits of Local Fertilizer Production

As opposed to importing pre-made foreign fertilizers, local fertilizer production has innumerable benefits for Malawi. These are summarized below:

- Accessibility for farmers: Producing locally (specifically granulating filler with local materials) means that Malawi is only required to import between 60% and 75% of its raw materials depending on the finished compound. As transport is one of the most significant cost components of fertilizer, local manufacturers can produce relevant fertilizer at a lower cost to the end user, thereby making fertilizer more accessible to farmers.
- Supply chain: By utilizing local transport and adjacent supplies like bags local fertilizer production uses and promotes investment in the local supply chain.
- Labor: producing fertilizer locally also increases sustainable demand for local labor. Malawi Fertilizer Company provides ~350 full-time jobs in Liwonde alone.
- Utilities: Both production processes require a significant amount of space for fertilizer production, bagging, and storage. The two fertilizer production companies own and/or rent properties for fertilizer blending & granulation facilities – benefiting the local government through property taxes, city rates (Optichem is in Blantyre), and utilities such as electricity and water.
- Forex: Incorporating local content (such as filler) displaces forex. Under local fertilizer production, Malawi will also save $ millions per year by not carrying in low nutrient content from China and other origins and adding the low nutrient content locally.

- Suitability: Local fertilizer production can provide farmers with a compound fertilizer suitable to their local soils, recognizing that soils vary greatly across the country. The importance of supplying farmers with appropriate formulations to suit local soils has until now, not been addressed. However, MFC has managed to solve this problem through blending; MFC now supplies a number of large estate sector customers with fertilizers tailored to their specific soil and crops requirements. MFC is also working to increase farmer awareness of alternative fertilizer formulations that will be more suitable to their local growing conditions. In summary, the blending of tailor-made compounds for specific local environments will improve the yields and financial returns of fertilizer use for farmers. This also matches the need for agricultural intensification in Malawi more generally. In order to significantly intensify production, it is critical that farmers have access to suitable/bespoke fertilizers.
- Sophistication: Both steam granulation and blending allow for specialization of fertilizer formulation to match customer's crop and soil needs. The technical specification of formulations increases demand for technical/sophisticated jobs - creating opportunities for graduates from major Malawi universities including LUANAR, Chancellor College, Polytechnic, and Natural Resources College.

Opportunities Going Forward

On 8th April, 2021 the new National Fertilizer Policy was officially launched. In his opening address, Minister of Agriculture Honorable Lobin C. Lowe, stressed the opportunity for local fertilizer manufacturing in Malawi. He emphasized that we need to attract domestic and international investors to increase our local manufacturing. The two existing fertilizer production companies are currently blending about 385,000 MT of fertilizer per year (if run at full capacity), which is about 85% of total annual fertilizer consumption. Therefore, we still have room for improvement.

The National Fertilizer Policy specifically prioritizes the development of the fertilizer industry. Under *Policy Priority Area 5: Private-Sector Led Fertilizer Industry Development* the policy lists the following strategies to encourage private sector investment in the fertilizer industry:

- Promote access to information on financing sources for investments in the fertilizer industry
- Attract venture capital funds to invest in the fertilizer industry
- Create financing facilities to cater for agrodealers and SMEs
- Facilitate loan guarantee schemes to reduce lending risk for fertilizer enterprises
- Facilitate matching grants and loans
- Facilitate long-term financing for large capital investments in the fertilizer industry

Mineral fertilizers play a central role to achieve the yield and returns expected by farmers and required by a growing population. Creating and promoting opportunities for investment into the fertilizer sector in Malawi is critical to increasing yields and achieving sustainable food security. Promoting fertilizer production in Malawi could be done through a number of channels. Concessionary tax rates to fertilizer producers - blenders or granulators - would enable companies to pay off investment faster and would stimulate further investment. Finance facilities specifically for agribusinesses looking to invest in fertilizer production would decrease barriers to entry and stimulate market competition. Finally, giving fertilizer producers preferential status for future government procurement would prioritize those companies who are benefiting local supply chains and local labor.

Conclusion

Malawi is unlikely to have the capability to manufacture fertilizer as the production of Phosphate and Potassium raw materials in Malawi is not currently feasible. The Phosphate deposit that is available is not of a high enough quality to extract commercially and we do not have Potassium deposits. Therefore, Malawi will not be able to become a major manufacturer of fertilizer in the foreseeable future due to the lack of potassium, a high-grade phosphorus, and a cost-effective source of nitrogen, all of which are needed for the production of fertilizer. Therefore, Malawi remains with two options for the production of fertilizer.

The first option that is already possible is for Malawi to import the nutrients and combine them according to formula specifications suitable for our soils through the processes of steam granulation or bulk blending. This provides us to opportunity to reduce the cost of fertilizer by increasing the incorporation of local content which reduces the logistics costs, encourages the development of local industry and reduces the overall forex requirement for fertilizer. Subsequently, this would bring down the price of fertilizer for the consumer and positively impact the local agricultural industry.

The second option is the Green Ammonia process which presents an opportunity to produce Nitrogen locally. The current Malawian smallholder maize fertilizer regime – 1 bag of NPK 23.10.5 + S + Zn & 1 bag of Urea – means that Nitrogen comprises over 76% of the nutrients applied. Therefore, for Malawi to become less reliant on imported fertilizer nutrients perforce means that it needs to focus on how local Nitrogen production can be achieved, given the country's lack of resources in Phosphorus & Potassium.
The technology exists to enable that ambition to become reality. It has already been proven in Zimbabwe where hydroelectric power was used to electrolyse water generating Hydrogen that was then combined with Nitrogen from the air to produce

Ammonia. Ammonia was then reacted to give Nitric Acid which, combined with more Ammonia, produced Ammonium Nitrate (AN). However, due to the increasing cost of electricity, that project was eventually abandoned.

Malawi does have one key energy resource in abundance – sunshine, and with the ever-increasing efficiency of Photo-Voltaic panels, it is now economically viable to use solar power to electrolyse water and create “Green” Ammonia. Thus enabling the country to become self-sufficient in its main fertilizer nutrient requirement.

Currently, Kenya is embarking on its own solar-powered “Green” Ammonia project, and in the current global context of rising fertilizer prices Malawi urgently needs to seize the opportunity to position itself to do likewise.

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Feeding the soil, feeding Malawi

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