

The SDGs and Sustainable Fertilizer Production



The 17 Sustainable Development Goals are of paramount importance to the planet and humanity. The International Fertilizer Association (IFA) and its members find them a very useful tool for promoting the more sustainable production of fertilizers.

By providing plants with concentrated, consistent and readily available nutrients¹ that are vital for their growth, health and resilience to climate stress, mineral fertilizers are key for global food security. Currently responsible for around half of the world’s food production, mineral fertilizers will be vital to increase productivity on existing farmland to feed the world’s estimated 9.7 billion people by 2050.

At the same time, the industry is fully aware of fertilizers’ contribution to global GHG emissions (2.5%), as well as the potentially negative impacts that an excess of nutrients in ecosystems can cause and is committed to reducing its environmental footprint.

To help tackle the 1.5% of global GHG emissions that come from fertilizer application, the industry endorses crop- and site-specific Best Management Practices, consistent with the “4R” Principles (applying the right source of nutrients, at the right rate needed to optimize yields for a specific crop, at the right place in the field, and at the right time needed by the crop), that help ensure that more food can be grown on existing farm land and that nutrients are used efficiently, minimizing losses to the environment.

For the fertilizer industry, sustainability also goes well beyond application. To help deal with the 1% of GHG emissions that come from fertilizer production, and reduce the overall environmental footprint of fertilizer production, manufacturers are working hard to increase energy efficiency, reduce emissions, cut water consumption and increase water recycling. The industry is also committed to ensuring safety and security at their production sites and beyond. To achieve this, producers are constantly updating their production methods, adopting Best Available Technologies and even pioneering new innovations.

1. Plant nutrients play specific roles in plant growth: nitrogen (N) is an important component of proteins and nucleic acids; phosphorus (P) allows plants to develop strong roots and is an important component of molecules involved in energy transfer; potassium (K) helps them grow in a healthy way and become resistant to drought and disease. Micronutrients such as zinc (Zn) help to improve better seedling establishment and higher plant tolerance to environmental stress factors.

Ammonia Plants: Increased Energy Efficiency; Decreased CO₂ Emissions

The production of ammonia is achieved through the Nobel Prize winning Haber-Bosch Process. This is the source of nitrogen fertilizers which are, along with phosphorus and potassium, the primary and most critical nutrients for plant growth. To produce ammonia, plants rely on natural gas or other hydrocarbon feedstocks, such as coal. Some 87% of the industry's total energy consumption goes into the production of ammonia. **Consequently, the energy efficiency of ammonia production is key** for reducing the industry's overall GHG emissions.

Best Available Technology (BAT):

Large gains have already been achieved in the last 30 years thanks to the adoption of BATs. Plants built today with the most advanced technologies use 30% less energy per tonne of ammonia produced compared to older plants; while older plants have also shown tremendous progress in cutting their energy requirements through improvements and upgrades on their production sites.

Carbon capture and reuse:

The capture and re-use of CO₂ emitted by fertilizer plants has enabled production sites to measurably and consistently reduce their GHG emissions from fertilizer production. IFA members around the world successfully capture hundreds of thousands of tonnes per year, and more producers are developing sound expertise in conditioning, handling and transporting CO₂ to be sold to other industries. Many of them are also working with regional governments around their sites to share their experience in handling CO₂.

Carbon neutral production:

Academic institutions, R&D centres, and a number of IFA members, are also working on techniques to produce ammonia entirely from sustainable, carbon-neutral inputs, like recycled hydrogen or renewable electricity. With a number of pilot projects currently in operation focusing on electrolyzers, and next-generation technologies such as electrochemical processes, photocatalytic devices, and advanced nuclear concepts being developed, carbon-neutral nitrogen fertilizers produced from "green ammonia" could be in widescale commercial production within decades.

Advances in Catalytic Processes Proven to Reduce Nitrous Oxide (N₂O) Emissions:

N₂O (nitrous oxide) is a byproduct from nitric acid production, which is critical for the production of nitrate fertilizers and for several important industrial chemicals. Since N₂O has a global warming potential of 300 times more than CO₂, the reduction of N₂O emissions is of utmost importance for this industry. By pursuing innovative technological solutions, some fertilizer producers have already achieved an aggregate reduction of over 85% of N₂O emission, and a potential of 90-95% could be achieved with a widescale implementation.

Phosphate And Potassium Plants: From Waste to Value

Phosphate and potash companies have put into place various locally **adapted recycling measures for water or electricity, such as:**

Water re-use:

Phosphate producers have developed programs to reuse up to 95% of the water previously used in transporting and processing phosphate ore. In Canada, for example, fertilizer companies that use solution mining have committed to recycling up to 90% of the water used in their facilities which has contributed to a reduction of up to 15% of groundwater withdrawals from 2005 to 2017.

Land re-use:

Phosphate and potash producers also have a range of schemes in place to reclaim land used for mines and other productions purposes. In 2017, for example, producers operating in the U.S. reclaimed 1,172 hectares of land.

Phosphogypsum re-use:

The industry is also pursuing the reuse of phosphogypsum (PG), a byproduct of phosphoric acid production. Major producing countries have already opted to remove obstacles to the beneficial uses of PG, leading to the consumption of millions of tonnes per year, which would otherwise go to waste.

In many regions worldwide, public-private partnerships are being developed to find beneficial applications. Spain, for example, is re-using PG as a sulphur fertilizer in agriculture. PG has also been shown to significantly increase the yields of a wide range of crops by improving acidic subsoils. By improving the condition of saline soils, PG has already been successfully used for land reclamation (near Huelva, Spain). Various countries including India and Russia are using PG as a cement co-product for road construction, while in Belgium and China, some fertilizer producers are processing it to be used for cement and plasterboard.

A Growing Focus on Recycling

Nutrient recovery:

IFA members are actively pursuing phosphorus recycling to support sustainable agriculture and the circular economy. These projects will enable the industry to be less dependent on mining and remove secondary phosphorus from waste products that can have an environmental impact while also meeting new regulations. Several plant scale trials are under way to replace mined phosphates by recovering phosphorus from meat, bone and sewage sludge ash and as well as struvite. IFA members are also undertaking projects to capture nitrogen from wastewater and other sources such as food to recycle it into fertilizer, thus reducing their reliance on the Haber-Bosch process.

Converting waste heat into steam for electricity:

Facilities are increasingly converting the waste heat generated during fertilizer production into steam, which is then used through cogeneration to produce electricity to power other production processes and for their internal consumption.

IFA Benchmarks: Constantly Tracking Industry Performance

Since 2002² IFA has offered its members voluntary benchmarks to track their CO₂ emissions reductions, energy efficiency, environmental performance and safety in the workplace.

The benchmarks reveal that the overall energy efficiency for producing nitrogen fertilizers has been greatly improved over the last decades for participating members, although there still remains the potential for incremental efficiency improvements and CO₂ emissions reductions, especially in regions where coal is still used as the main feedstock.

IFA's Energy Efficiency and CO₂ Emissions benchmark, which has been running since 2004 and is oriented towards ammonia production, shows a continual improvement by participating members, mainly due to investment in plant revamps as well as new and efficient capacity coming online. Since 2004, a 14.5% reduction in the CO₂ emissions rate per ton of ammonia was observed and the current average net energy efficiency represents a 5.5% improvement over the first average measured. A comparison between world averages and best-in-class averages indicates that energy efficiency could be improved more by further adopting BATs.

IFA's Environmental Performance benchmark has been collecting industrial emissions data since 2003 from nitrogen, phosphate and potash fertilizer production sites located around the world.

The data collected in 2020 from close to 300 production sites on over 50 emissions to air, water and soil show a trend towards decreasing emissions thanks to a widespread adoption of environmental mitigation techniques across nitrogen, phosphate and potash production.

IFA's Safety Performance benchmark records lost-time injury (LTI) and total recordable injuries (TRI) for industrial sites located around the world since 2001. The loss-time injury rate per hours worked of IFA's members has improved by 67% in the past 18 years remaining well below 3 since 2007, and LTI and TRI rate averages for company employees and contractors show continuous improvements which demonstrates how far the industry has come in its efforts to achieve excellence in safety performance globally and showcase a industry's ongoing alignment with the United Nations' Sustainable Development Goals.

In 2019, IFA has formally agreed to partner with the International Energy Agency (IEA) to develop a Low-Carbon Roadmap for the global fertilizer industry sponsored by the European Bank for Reconstruction and Development (EBRD). This Roadmap will help the fertilizer industry to identify solutions it can adopt to reduce its emissions while maintaining its competitive position as a reliable source for supporting agriculture globally. The Roadmap will also help to guide the industry's actions over the coming decades and support companies in planning for a low carbon future.

2. IFA offers its environmental performance benchmark to all producer Members since 2002, and its energy efficiency and CO₂ emissions to ammonia producers specifically since 2004.

Member Case Studies: Fertilizer Production Innovation

ABU QIR FERTILIZERS (EGYPT)

Since 2006, under the umbrella of the Kyoto Protocol and through the Clean Development Mechanism (CDM), Abu Qir Fertilizers has worked with Carbon Austria to reduce its nitrous oxide emissions. The process consists of a catalytic reduction of NO_x and N₂O into nitrogen and water which can be safely released into the air. With annual reductions of around 1.035 million tonnes per year of carbon dioxide equivalents, the project has saved approximately 17 million tonnes CO₂ equivalents in twelve years and is one of the largest international projects of its kind.

Additionally, to reduce CO₂ emissions from the company's Ammonia II plant, the company has put in place a Carbon Capture project where excess CO₂ gasses are captured and sold to specialist gas producers such as Air Liquide, Mid Gas and Bargas to be liquified and sold to other companies for industrial applications.

To reduce the total amount of industrial wastewater lost, the producer's zero liquid discharge project reduces the residual ammonia concentration in wastewater, reacting it with sulphuric acid to make ammonium sulphate which can be used as a fertilizer. In this way 650m³/h of wastewater is treated to produce about 520m³/h of pure water which are used for the cooling towers. There is also a large decrease in the amount of chemicals required for treating the wastewater.

CF INDUSTRIES (USA)

In 2020, as part of their engagement to produce low carbon nitrogen fertilizers, CF Industries committed to build an initial green ammonia project at the company's flagship Donaldsonville Nitrogen Complex to produce approximately 20,000 tons per year of green ammonia. The company will install a state-of-the-art electrolysis system to generate carbon-free hydrogen from water that will then be supplied to an existing plant to produce green ammonia.

Additionally, the company is developing CCS and other carbon abatement projects across its production facilities.

The implementation of these projects will enable CF to produce low-carbon ammonia. The company estimates that over time it could produce approximately 3.5 million tons of low-carbon ammonia per year, which represents about one-third of its annual ammonia production capacity, without affecting its current product mix.

CF has also announced comprehensive ESG goals, covering critical environmental, societal, and workforce imperatives, including a dramatic reduction in carbon emissions across its global network by reducing the GHG footprint of its operations and in the utilization of its products. CF has also established a new committee, the Environmental Sustainability and Community Committee, to oversee all aspects of the progress toward net-zero carbon emissions and the company's active involvement in the communities in which it operates.

In order to execute these initiatives, CF is collaborating with leading technology companies, and has signed Memorandums of Understanding with ThyssenKrupp and Haldor Topsoe. The company is in discussions with global utilities and maritime transportation providers that have announced their intention to use low-carbon ammonia directly as a fuel.

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GPIC (BAHRAIN)

To increase energy efficiency, in 2018 GPIC implemented several modifications to their plants in Bahrain that resulted in natural gas savings of more than 28,317 Nm³ every day. By using three turbines/motors driven high pressure BFW Pumps instead of the previous four pumps, the company was able to meet the boiler feed water demand while saving energy. Additionally, a new carbamate condenser with a higher surface area was installed to recover more process heat and generate excess low-pressure steam which was routed from GPIC's Urea plant to its Carbon Dioxide Recovery (CDR) plant, thus conserving a substantial quantity of natural gas from the CDR plant's dedicated gas fired boiler.

Furthermore, the company made a range of other improvements designed to make their manufacturing process more efficient and sustainable including a 22 MTPD Urea Formaldehyde (UF-85) plant for captive consumption designed to make the existing operation more reliable while eliminating the potential safety and environmental hazards of importing Urea Formaldehyde to produce urea granules.

Other innovations include a 11kV Capacitor Bank installed to reduce reactive power import resulting in substantial direct electricity grid use savings per month and increased sustainability of the Bahrain power grid (2014), and a Carbon Dioxide Recovery (CDR) plant that has captured more than 1.3 million tons of CO₂ from Methanol Reformer flue gases that helped improve production efficiency, increasing daily Urea production by more than 175 MTPD and Methanol production by 120 MTPD.

The company also exerted all its efforts to optimize its energy consumption by utilizing all the surplus low pressure steam within the complex, and routing it to its CDR plant and so shutting down its dedicated gas fired boiler in 2020. In addition, the Gas Turbine load was optimized to improve overall energy and economics under the current challenging circumstances as products prices are low.

ICL (THE NETHERLANDS)

In 2019, ICL opened a Phosphate Recycling Unit in Amsterdam, the Netherlands. The facility will allow the company to retrieve phosphates from alternative sources for the production of phosphate-based fertilizers on an industrial scale. The site recycles phosphates from sewage sludge ashes, meat and bone meal ash and struvite (magnesium ammonium phosphate) which would otherwise be wasted. Complying with relevant legislation, the plant can produce fertilizers that replace between 5% and 100% of the phosphate rock input. ICL plans to further increase the use of phosphate coming from alternative sources in the coming years and become one of the international frontrunners in phosphate recycling.

IFFCO (INDIA)

Water conservation has long been a focus at IFFCO's Ammonia and Urea producing Aonla Unit in Northern India which has deployed a series of upgrades to reduce water consumption over the last 20 years.

The company has reduced the water consumption used for regeneration purposes in the demineralization (DM) plant. The installation of filters to avoid the treatment of the turbine condensates in the Ammonia-I and Ammonia-II plants, have saved 10800 m³/year of water. The plant also uses an alkaline effluent instead of freshwater to absorb acid fumes from the hydrochloric acid storage tank which has saved an additional 0.15 million m³/year of water.

Further, limits of Chloride content in circulating Cooling Water had been increased from 300 mg/L to 500 mg/L in all Cooling Towers. Now Cycle of Concentration (COC) of all Cooling Towers is improved to more than 8-8.5. This results into reduction of Cooling Tower blow down thereby reduction in fresh make-up water of 0.79 million m³/year.

To increase water recycling and conserve groundwater, IFFCO Aonla Unit had installed roof-top rain water harvesting in various buildings since 2009. Now, covering a total roof-top area of around 25,000 m², the total annual water recharge was 19,564 m³ in 2018. Further, by using treated effluent water for horticulture purpose, an additional 1,800,755 m³ of fresh water is also saved on annual basis.

Energy saving has also been an important consideration at the plant. Since 2015, IFFCO have implemented a series of modifications that have helped to reduce specific Energy consumption by 4% per million tonnes of Urea in two years. In 2017, IFFCO made a series of technical upgrades for Energy savings. The replacement and revamps of several parts of the CO₂ compressors lead to a higher energy efficiency with a reduction in steam used equivalent to 0.4 million m³/year of water.

Other innovative energy saving projects include installing a modified system to use flash steam generated in the steam condensate tank as a motive fluid in the booster ejector installed in the Urea-I plant. Allowing heat from the condensation of flash steam, which was previously being dumped in cooling water to be used in the Urea plant, has thus saved around 1.8 Mt/hr of high-pressure steam and 9190 Gcal/year of energy.

In addition to using renewable solar energy for water heating, street lights, and power various buildings, the facility also reuses waste materials, utilizing a Purge Gas Recovery unit to recover and recycle hydrogen to save energy, using waste heat for natural gas fuel heating from the primary Reformer flue gas.

As a result of these innovations, the plant is becoming increasingly Energy efficient while also reducing its environmental footprint. The amount CO₂ generated per Mt of Urea, for example, has fallen from 0.523 in 2015-2016 to 0.393 in 2019-20.

OCP (MOROCCO)

OCP aims to produce all of its energy from wind, solar or cogenerated energy and for its total water consumption to come from desalination or waste water treatment. Currently 70% of all its energy needs come from these sources with three quarters of all OCP's mines entirely served by wind energy. Producing 40% of Morocco's renewable energy, the company has avoided around 2 Mt CO₂ eq/year.

In 2018, the company built a pipeline for transporting phosphorus slurry from the mine to the fertilizer production plant. By taking advantage of gravity the pipeline removes the need for energy to dry and transport phosphate, avoiding 400 KT of CO₂/year while also allowing for 1.3 Mm³/year of water used for phosphate washing to be recovered.

In total 30% of OCP's water requirements are already covered by desalination and waste water treatment and reuse. In addition to the pipeline, 80% of the water used in its mines is recycled, ground water is saved for irrigation and communities usage, 10 Mm³ of wastewater is treated annually with 40 Mm³ targeted by 2028 and 26 Mm³ of seawater is currently desalinated with the aim of reaching 108 Mm³ by 2028.

To maximize energy cogeneration OCP has invested in dedicated heat recovery systems in their sulphuric production units. The recovered steam during the absorption process of sulphuric acid production covers an additional part of the plant needs, resulting in less high-pressure steam consumption and 20% more energy production.

Inaugurated in 2016, OCP's integrated fertilizer production plant in Jorf Lasfar includes BATs to reduce its environmental impact. The project was designed for optimal management of water and energy and to ensure compliance with the most restrictive environmental standards to reduce water, energy, resources and emissions and ensure energy autonomy. Additionally, zero fluor is released and almost all it is recovered, while SO₂ emissions have been reduced by 70%.

OCP's carbon farming project aims to reclaim marginal lands by afforesting currently treeless areas like arid, semi-arid zones and old mining sites which could become major CO₂ sinks as well as stabilizing and improving the soil structure. The project has identified seven tree species with high growth rates and added value for the region (check which region), uses three irrigation levels and two types of soil amendments to promote growth. So far 4.5 million trees have been planted.

With innovation in renewable energy a priority for OCP, the company has also partnered with a variety of different organizations to research green ammonia, phosphate-based materials for thermal energy storage, adapting solar cells for usage in reclaimed mines with high dust atmospheres and the solar drying of washed phosphate rock.

PRAYON (BELGIUM)

Prayon has developed a special purification technology that cleans phosphogypsum so that it can be sold rather than stacked. Prayon's double crystallisation process extracts fluoride and phosphate to produce around 800 kt of commercial grade phosphogypsum annually which is sold to plasterboard producers and cement manufacturers. With a typical 96% removal of fluoride and 99% removal of phosphate, the high quality of Prayon's gypsum makes it very suitable for plaster applications. The process is also self-drying which reduces fuel oil consumption for process it. Prayon's process helps to ensure eco-friendly stacking, an additional revenue stream and increases the choice of phosphate rock sources that can be used for producing phosphorus-based fertilizers.

QAFCO (QATAR)

To minimize CO₂ venting during ammonia production as well as avoid shutdowns due to shortages, QAFCO installed a system to share CO₂ between 6 plants. Provisions for pressure control and blowers are available to guarantee the CO₂ sharing as well as coordination procedures for different operational cases guided by one CO₂ coordinator. The company also recycles more than 95% of their total water withdrawals.

YARA (NORWAY, AUSTRALIA, FRANCE AND THE NETHERLANDS)

Yara's most significant initiative to reduce GHG emissions has been the development and installation of N₂O catalysis technology at its nitric acid plants. This technology removes more than 90% of the N₂O emissions in Yara's plants and is also commercially available to third parties. Yara has since 2005 reduced its scope 1 emissions by almost 45%, primarily through N₂O abatement in nitric acid production and has several initiatives in place to further reduce N₂O and improve energy efficiency and thereby reduce direct emissions by another 2 Mt CO₂eq/yr.

Yara has several projects under development in the Sluiskil (Netherlands), Porsgrunn (Norway) and Pilbara (Australia) aiming to produce low-carbon fertilizer using renewable energy to produce green hydrogen as feedstock. The projects are planned to go onstream from 2023 and 2024. The demo projects will give a reduction in CO₂ emissions of 187 000 t CO₂ per year. These demo projects are the first projects and set the direction for future plans and ambition to be climate neutral by 2050.

In 2019, Yara signed an agreement with global resource company Veolia to develop Circular Economy in the European food and agricultural chain. The expert partnership integrates Veolia's access to growing volumes of recovered nutrients from waste and expertise in handling organic materials with Yara's mineral fertilizer production expertise and crop nutrition knowledge. Together the partners evaluate opportunities related to P and N recycling, with the aim to utilize them directly in Yara production processes, in small industrial loops. Another focus is on food waste valorization as organic based fertilizers.

A first case is based on the recovery of ammonia emissions from compost sites, and its valorization as a Yara odor control product. Yara Montoir (France) has finalized a commercial collaboration for the reuse of P in its production facility aiming to substitute up to 5% of the primary P need in the NPK production. Yara Porsgrunn (Norway) is using as raw material Ammonium Nitrate that is recovered from the Oslo wastewater treatment plant.

Yara Sluiskil (Netherlands) upgraded its existing ammonia plant in 2018 by introducing a hydrogen pipeline connection that helps to reduce its reliance on fossil fuels. The world's first converted natural gas pipeline ensures the efficient and safe transport of hydrogen, which was previously a waste-product at Dow's nearby ethylene cracker, can now be used as feedstock. The project has resulted in CO₂ savings of 10,000 tonnes and energy consumption savings of 1 50,000 gigajoules per year. A similar concept is implemented at large-scale in Yara's Freeport facility in Texas (USA).

In addition, the WarmCO₂ project consists of a modern greenhouse complex that utilizes residual heat and CO₂ from the adjacent Yara Sluiskil fertilizer plant. Showcasing technical solutions and a sustainable business model for recycling industrial residual heat (1,700 TJ/year) and CO₂ (60 Kt/year), the project offers 50% savings on horticultural energy bills and has created 750 jobs.