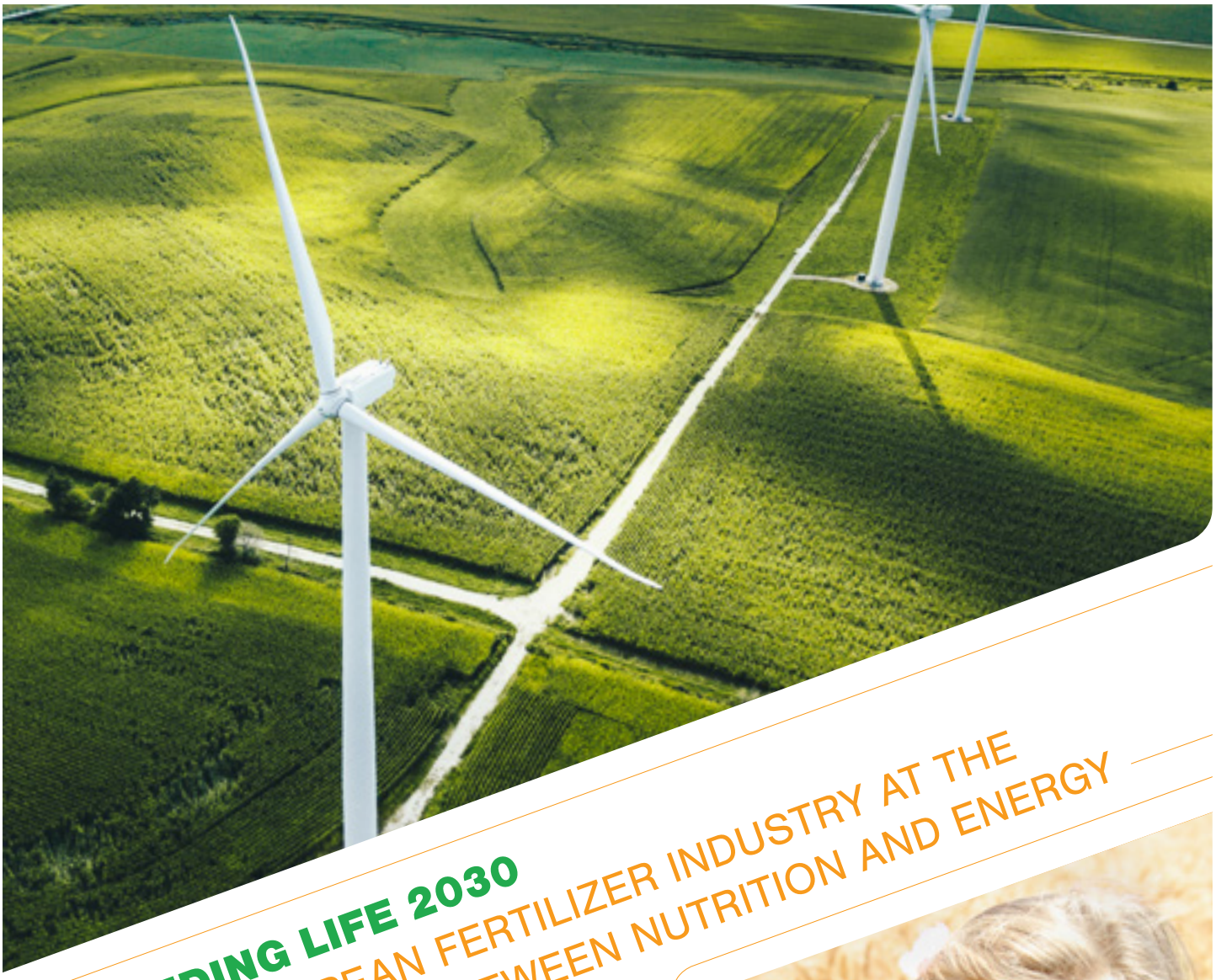

FEEDING LIFE 2030

THE EUROPEAN FERTILIZER INDUSTRY AT THE CROSSROADS BETWEEN NUTRITION AND ENERGY

fertilizers europe

30 years growing together

Published by Fertilizers Europe
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About Fertilizers Europe

Fertilizers Europe represents the majority of fertilizer producers in Europe and is recognised as the dedicated industry source of information on mineral fertilizers.

The association communicates with a wide variety of institutions, legislators, stakeholders and members of the public who seek information on fertilizer technology and topics related to today's agricultural, environmental and economic challenges.

The Fertilizers Europe website (www.fertilizerseurope.com) provides information on subjects of relevance to all those interested in fertilizers' contribution to global food security.

About this report

The aim of the 'Feeding Life 2030' exercise is for Fertilizers Europe to produce a forward-looking report on the production and use of mineral fertilizers in Europe by 2030. The report is both an internal reflection and the result of consultations with a wide range of stakeholders.

Fertilizers Europe has held a number of internal discussions on the future of the European Union's mineral fertilizer industry and the agri-food sector. It has also conducted a wider dialogue with stakeholders and the EU institutions, via an online survey - 'The European fertilizer industry in 2030' - and by conducting in-depth interviews with key players from all parts of the agri-food and fertilizer supply chain.

The aim of the survey and the interviews was to obtain a picture of the needs of European society in general, and the EU agri-food sector in particular, and to inform the 2030 study's contents, notably on the challenges the industry faces and the main driving forces shaping the future. Fertilizers Europe would like to thank those who took part for their time and their valuable insights.

The following chapters set out Fertilizers Europe's Vision, and illustrate how the Vision reflects the views of all actors within and outside the fertilizers industry.

Introduction

I am delighted to present the Vision of the European mineral fertilizer industry towards 2030 and beyond.

This Vision illustrates our industry's forward-looking approach in addressing societal challenges. It aims to facilitate dialogue with key stakeholders on the future role of our industry in the context of the European Union's ambition to lead sustainable agricultural production and to maintain a strong industrial base while moving towards a decarbonised society.

Fertilizers Europe celebrates its 30th anniversary in 2018. When I joined the sector in 2002, the fertilizer industry had a reputation as a traditional, even slightly old-fashioned industry. That was before the food crisis in 2007-2008, which highlighted the importance of food production and which brought the fertilizer industry back into the limelight as a sector of the future.

A decade of change since then has transformed our industry. The European mineral fertilizer industry of 2018 represents an important EU industry in terms of turnover, employment and, most importantly, its value to the agri-food sector. It has accepted the need to improve its environmental performance. Fertilizer producers have cut Greenhouse Gas emissions by more than 40% compared to 2005 and other industrial emissions have also been reduced. The discussion on the circular economy has brought home to many the important role of the fertilizer industry in optimising resource use and in using industrial by-products and other recycled raw materials in our production.

These days when I engage with stakeholders, it is clear that perceptions have changed, and we are often expected to help come up with solutions to the most pressing issues in our society.

So, we have a good story to tell, but it doesn't stop here. We will continue to move forward. Therefore, we decided to look ahead to 2030 by undertaking an exercise to identify the drivers of and barriers to the industry's future performance. This has helped us develop a long-term Vision for our industry in Europe.

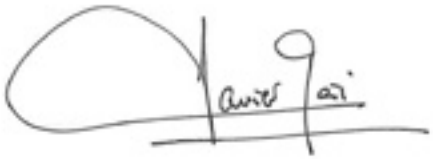
We also invited key stakeholders in Europe's agri-food value chain, ranging from farmers to industry representatives, NGOs and academia, to share their views on the main drivers and trends that are likely to shape the future of fertilizer production and use.

On the fertilizer use side, rapid technological development and innovation offer the prospect of meeting future food needs more sustainably. Digital farming offers big potential for further progress in nutrient management in Europe.

On the production side, Europe is forging ahead with the transition to clean energy, and is relying increasingly on renewable energy sources. We are a part of this drive. The nitrogen fertilizers industry as a producer of ammonia offers the key to unlocking clean energy potential by acting as a carbon-free energy storage medium.

I am convinced that the pathway for the evolution of the mineral fertilizer industry projected in this report is ambitious but also realistic. It requires genuine commitment from industry leaders and decision-makers. It can be achieved through a well-designed EU policy framework that will act as an enabler for this Vision, allowing the mineral fertilizer industry to evolve in line with the EU's ambitions while retaining its economic viability against global competition.

I am confident that this report will lay a foundation for a constructive dialogue with policy makers and other stakeholders on how to tackle the future challenges of food and energy. It is a dialogue I am proud to be part of.



Javier Goñi del Cacho
CEO Fertiberia, President of Fertilizers Europe

1.

Key Messages

Fertilizers are truly at the crossroads of nutrition and energy.

It is widely recognised that mineral fertilizers feed about half of the global population. It explains the abundance of food in Europe, where a large majority of farmers apply fertilizers to enhance the yield and quality of their products. The challenge is to improve the efficiency of fertilizer use, and the solution lies in applying 'more knowledge per hectare'.

Today's production of nitrogen fertilizers is energy intensive. Natural gas is used as a raw material to produce ammonia, the building block for all mineral nitrogen fertilizers. But ammonia can also be produced from green electricity, and since ammonia is both easy to transport and a great way of storing energy, it will play a pivotal role in the energy transformation towards a low carbon economy.

The mineral fertilizer industry's Vision for 2030 falls in two parts: The way fertilizers are used and the way they are produced. In both areas important changes are feasible and likely.

Applying more knowledge per hectare

Applying 'more knowledge per hectare' is the key Vision for how fertilizers will be used in 2030. This insight has come from many different contributions. Better fertilizer products and products more targeted to the specific crop, encompassing the latest knowledge and combining different technologies, are an important part of this. So are new tools allowing for real-time assessment of the fertilizer needs of crops in the field which, combined with GPS and intelligent equipment, makes it possible to adjust application so the plants are fed according to their needs. This will be made possible by the farmers and growers of the future who will be even better educated and operate larger units making investment in machinery and knowledge pay a decent return. The application of knowledge will also have a very positive effect on the environment as better and more targeted fertilization will increase the growth of plants and thereby diminish losses to the environment thus leaving more space for biodiversity and nature.

Taking on challenges

'Taking on challenges' is the Vision when it comes to the production of fertilizers in 2030. As the major producer of ammonia in Europe, the nitrogen fertilizer industry is likely to play an important role in the storing, transportation and conversion of green energy based on hydrogen, as ammonia is the 'missing link' in the coming energy transformation. More flexible production of ammonia will become the norm. The industry will also be challenged by the demand for better and more targeted fertilizers, and it will increase its efforts in terms of innovation and product development, being ready to take advantage of new science and technologies related to plant growth. Finally, the role of the fertilizer industry as a key contributor to the circular economy will be firmly established and new sources of recovered raw materials will be extensively used.

The Vision presented here is forward-looking and underlines that the fertilizer sector can contribute to solving important challenges for our future society. At the same time, it is important to recognise that the mineral fertilizer industry is a global industry. Large amounts of fertilizers are traded between continents and competition between producers is fierce. Policy-makers need therefore to pay attention to the competitive situation of the European industry as a level playing field is crucial for positive development to take place. Furthermore, a policy framework underpinning the positive Vision needs to be created.

2.

At the crossroads between nutrition and energy

The Vision of Fertilizers Europe for 2030 has to answer the question of how to produce enough nutrients for the plants that are needed by a growing global population, in a more energy and environmentally efficient way, while at the same time helping find solutions to other societal challenges such as meeting the growing demand for cleaner energy and better use of resources.

Feeding the world

Production of food continues to be a major challenge for the planet. Global food supply will need to rise to match population growth in the coming years, as well as meeting the needs of an estimated 800 million people who are currently undernourished. The United Nations estimates that the world's population will reach 8.6 billion people by 2030, up from 7.6 billion today. This represents an annual increase of approximately 80 million people per year. In other words, we need to find a way to feed an extra Germany every year. This is not an easy task as expanding cities and new infrastructure eat up prime farm land. The world will therefore need to farm more efficiently to produce enough food.

At the most basic level food comes from plants. Plants are the basis of our food systems, and they are experts in transforming energy. Using photosynthesis, plants transform the sun's energy and CO_2 into plant energy in the form of carbohydrates and fats and they convert mineral nutrients such as nitrogen into proteins and vitamins. The amount of energy thus generated as biomass is massive. For the plants to be able to transform the sun's energy, they need water and nutrients. This is where fertilizers - crop nutrients - play a crucial role. Mineral fertilizers complement manure and supply the nutrients needed by plants to make the most of the energy of the sun.

In 2008, researchers from Wageningen University in the Netherlands argued that fertilizers, in effect, fed 48% of the global population.

Not least thanks to fertilizers, the EU is able to feed itself without major problems, so the European challenge lies more in producing food in the most sustainable way. The EU is thus in a situation that differs from many other world regions.

Producing and storing energy

Whereas important mineral fertilizers like phosphate and potash are mined, nitrogen fertilizers are currently produced by combining the hydrogen molecules in natural gas with nitrogen from the air to form ammonia, the basic building block of all fertilizers. This makes nitrogen fertilizers a very energy-intensive product. Even so, there is so much energy captured in plants that a rough calculation shows that for every unit of energy used to produce nitrogen fertilizers, six units of energy in the form of biomass are created.

It is the energy-intensive nature of food production and fertilizers, not least nitrogen fertilizers, which makes this sector so important for future energy discussions. As the EU progresses towards decarbonising its energy supply and relying more on renewable energy, such as wind and solar power and the production of hydrogen, the question of hydrogen storage

becomes more pressing. Ammonia is made from hydrogen and air, and since ammonia has such high energy content and is easy to transport, it has huge potential as a mean to store hydrogen i.e. clean energy. It is the 'missing link' in making decarbonisation work.

The crossroads

The challenges of future food production and of decarbonising the energy sector are enormous. Fertilizers will be at the crossroads where these two challenges meet. Fertilizers will play a crucial role looking forward to 2030, and enabling the EU's ambition of a clean, modern and sustainable economy in 2050.

In the following sections of this report, the Vision of the European fertilizer industry towards 2030 will be presented. The Vision is presented in the hope that stakeholders and the public will get involved in a fruitful discussion of how to tackle the future challenges of food and energy. The report highlights key drivers for the fertilizer industry and points to likely developments expected between now and 2030. The final section examines the kind of policy framework that is needed to sustain the Vision.

In the annexes, the reader can find further information on the fertilizer industry in Europe and the interviews and surveys carried out to prepare this report.

3.

Feeding Life – Fertilizers Europe's Vision for 2030

Fertilizers Europe's Vision for 2030 is ambitious, requiring support and commitment from industry, stakeholders and policy-makers. It is centred on the fundamental question of how to produce and supply sufficient nutrients for plants to be grown in the right quantity, and of the right quality, to feed people in a more energy-friendly, environmentally-sustainable and efficient way.

At the same time, particularly in the EU, the fertilizers industry is looking for solutions to meet other societal challenges such as lowering GHG emissions, developing cleaner energy sources and making better use of resources. The industry is committed to contribute with solutions to the challenges of our future society. This will help secure the economic basis of the European mineral fertilizer industry. It will also make the sector an employer of choice for new generations. This is an important part of the ambition behind our Vision.

3.1. Fertilizer use

Mineral fertilizers are an essential part of crop nutrition. Plants receive their nutrients from both organic sources (such as manure) and mineral fertilizers (mined or coming from the ammonia production process). In the future, mineral fertilizers will remain an essential source of nutrients for the plants, as they are needed to balance and supplement organic sources in order to give plants the optimal growing conditions.

A. Supporting the professional farmer of the future

It is farmers and growers who use fertilizers in practice to produce food. The Vision foresees that professional farmers and growers will become even more knowledgeable and demanding of nutrient input by 2030. Furthermore, the face of European farming will change. A new, better-educated generation of farmers and growers will operate much larger enterprises, or at least units with higher turnovers, either alone or in close cooperation with colleagues, and they will be using fertilizers much more efficiently and precisely.

More specifically, farmers in 2030 will focus increasingly on nutrient use efficiency, in order to produce sustainably and profitably by optimizing overall application and increasing yields. In order to do this, farmers will rely more profoundly on advice, planning and new tools and technology that allow them to apply fertilizer where it is required in the amount that is needed. And more specialised and diverse fertilizer products will be needed.

It is also very likely that by 2030 specialised contractors will play a bigger role in applying crop nutrients in EU agriculture. These contractors will have the necessary turnover and incentive to invest in the newest equipment in order to make efficient use of data-driven machinery and other tools, which will make the use of fertilizers more sustainable. Many farmers will choose to outsource the application of fertilizers in order to be able to concentrate on other parts of their businesses. This will entail changes to current business operations and distribution channels, and fertilizer producers will need to concentrate more on their relationships with farmers.

B. Applying more knowledge per hectare

Return on investment in fertilizers will be even more in focus by 2030. Increasing returns can be achieved by ensuring that farmers and growers apply the right nutrients to their plants at the optimum time. To do this requires excellent information. Knowledge in terms of plant nutrient uptake and field distribution of crops will guide the practical application. The objective is to optimise fertilizer use by fulfilling actual plant needs.

In 2030 it is possible that European farmers will focus even more on specialised production and high value crops, leaving other parts of the world to produce more ‘bulk commodities’. This

in turn will lead to a demand for more knowledge on nutrient uptake, more specialised types of fertilizers and knowledge on the best way to fertilize these crops.

A higher degree of knowledge will be supported by technology based on site tools and instruments measuring nutrient uptake in plants. Such technology is more reliable and faster than measuring soil nutrient content, and even more importantly these new solutions will allow for real-time adjustment of fertilizer application rates, and split applications over the season coming closer to feeding the plant according to its needs. The supply of services and advice based on the new tools will become part of adding knowledge.

The importance of all nutrients, including primary nutrients (nitrogen, phosphate and potash), secondary and micronutrients, will be included in all on-farm decision-making in order to maximise efficient plant growth. Better understanding of nutrients will be an integral part of farm knowledge and advice and the planning of nutrient application. Specialty fertilizers, that take into account greater use of knowledge and advice and can increase the return on investment in high value crops, will likely to become more important.

C. Getting ahead of regulatory pressures

In 2030, the use of fertilizers will continue to be heavily regulated.

The combined application of manure and mineral fertilizers will continue to be guided by the Nitrates Directive and its national implementation rules. More countries will probably establish rules on nutrient accounting or nutrient balance on individual farms. Tools that promote nitrogen use efficiency, in particular, will become part of good agricultural practice and form a basis for agricultural support schemes.

Rules concerning clean air and especially ammonia emissions will become very important for the application of manure and mineral fertilizers in 2030. Rules concerning storage and the equipment for bringing out of manure will almost certainly be revised and strengthened and so will the rules on ammonia emissions from farm buildings housing animals. The application of mineral fertilizers on plants will also be affected as a consequence of limits on ammonia emissions. Fertilizers with high ammonia emissions, such as urea-based fertilizers, will have to be applied under special conditions or have inhibitors added that reduce the potential for ammonia emissions.

This regulatory pressure will increase the cost of applying and producing fertilizers, but it will also lead to opportunities for differentiation and the marketing of services and advice.

It should be mentioned that fertilizer production itself will also face increased regulatory pressure. New rules will limit emissions from production facilities and control wastes and by-products from fertilizer production sites. Producers will focus even more on sustainable techniques and inputs, including raw materials.

3.2. Fertilizer production

Fertilizer production results from the large-scale conversion of nitrogen and hydrogen into ammonia and mining activities to source phosphate and potash and the transformation of such mineral products. It also encompasses the use of a large range of by-products and involves industrial symbiosis as part of a circular industry.

A. Making decarbonisation of energy possible

In 2030, the EU drive to decarbonise the economy is expected to be well advanced. Hydrogen will be a key factor in this process, because hydrogen can be used as an energy carrier and it does not contain carbon. Hydrogen itself however is a difficult substance to handle and transport. Ammonia is hydrogen in another form. Furthermore, ammonia is an easier, safer, and cheaper way to store and transport hydrogen than hydrogen itself. In addition, the technology to produce and handle ammonia already exists. Ammonia will therefore play an important role in advancing the carbon-free energy of the future.

By 2030 ammonia production units will be changing and will receive part, perhaps 10%, of their need for hydrogen from electrolysis based on electricity from renewable sources. Some ammonia units will have extra storage capacity, and this capacity will be used to level out production of renewable energy. There will be smaller units converting stored ammonia back to energy if needed locally. In short, ammonia production units of the future are likely to be flexible, able to use different sources of hydrogen, and to function as energy storage units and back-up energy producers.

The use of carbon capture and storage is also expected to have become a reality in some parts of Europe by 2030. Ammonia producers will continue to make use of CO_2 and they will be able to store their surplus CO_2 in concentrated form underground. Traditional ammonia production technology is an ideal starting point for carbon capture and storage.

B. Promoting the circular economy

The fertilizer industry's role in the circular economy is well established. The industry works to optimise resource use and recycles a wide range of by-products in its production process, turning them into valuable plant nutrients, and uses surplus energy and raw materials that derive from other production processes on fertilizer production sites or from production processes taking place elsewhere. In 2030, the synergies between fertilizer producers and industries such as nylon production will continue.

By 2030 industrial processes will become more focused on the possibility of recycling

by-products, and the fertilizer industry stands to become even more important as a recipient and user of such products.

C. Strengthening product development

With better educated and more demanding farmers focusing on more specialised production in 2030, the return for mineral fertilizer producers on investment in product differentiation and product development will increase. It will be possible to quantify and capture the value of premium fertilizers and application technologies and so the incentive for producers to increase research and development will become greater. This will also increase the interest in research in universities and other research institutions creating a positive dynamic for further knowledge.

Whereas it is reasonable to expect that in 2030 the 'standard' fertilizer products will continue to meet a large part of the demand from farmers and growers, it is also clear that specialised, 'intelligent' products focusing on a specific crop or application technology will become very important. Tailored fertilizers delivering higher yields and better quality for a particular crop will have become increasingly the norm. Differentiation of products will clearly also become more important.

Development of decision support tools, advice and services following these new tailored fertilizers will become part of the offer supplied by producers, and by 2030 it is likely to be a significant part of the value proposition to farmers.

A special area of product development will be in helping farmers make the most of animal manure both in terms of reducing losses to the environment and enhancing plant uptake by combining organic fertilizers with products originating from the mineral fertilizer industry.

3.3. Looking further ahead - how the industry could feed life in 2050

In terms of designing and building new production facilities for mineral fertilizers, 2030 is just around the corner. It is instructive to **imagine the world of 2050**, and see if the steps taken in 2030 will be in line with what could become reality.

If the European Commission sets an objective of net zero emissions economy, across all sectors, in 2050, this would be a huge challenge for the mineral fertilizer industry, given the natural gas-based and energy-intensive nature of nitrogen fertilizer production. Even though the fertilizer industry will already be moving in the right direction by 2030, there will need to be further fundamental and massive changes by 2050. While it is difficult to imagine nitrogen fertilizer production to be totally carbon-free without extensive use of carbon capture and storage, the good news is that with the technologies we know today such a future is realistic and possible, in principle.

In 2050 ammonia, which is the raw material for nitrogen fertilizer production, could be made from 'green' hydrogen derived from the electrolysis of water, powered by renewably-produced (green) electricity. This hydrogen will be produced at the most convenient sites where solar, wind or other forms of green energy are abundantly available. Ammonia can and will be produced near those sites, since ammonia is the most effective hydrogen storage available. But ammonia will also be produced at existing ammonia producing sites, connected to the hydrogen network via the former natural gas pipeline grid.

Since ammonia in this case will be used predominantly for energy storage and, furthermore, as it is the most likely replacement for Liquefied Natural Gas and Liquefied Petroleum Gas in the energy transport market, the production of ammonia for fertilizer use will form a smaller proportion of global ammonia consumption than today. To make ammonia available for the production of plant nutrients does not necessitate large production sites. Much smaller sites, closer to the major agricultural areas, could be used. Those areas are defined by climate, soil quality and water availability, rather than the availability of cheap gas. In such circumstances EU fertilizer production could be revitalised - the EU will just need to import raw materials such as phosphate and potash that form the basis of the other main plant nutrients and which can only be found to a limited extent in Europe. By 2050 it could be possible to obtain an important proportion of the major nutrients, such as potassium and potash, by closing a loop in the circular economy. For example, some raw materials will come from municipal water treatment units where valuable nutrients can be retrieved and made available for fertilizers. Alternatively, raw materials could be in the form of environmentally-processed manure-based pellets.

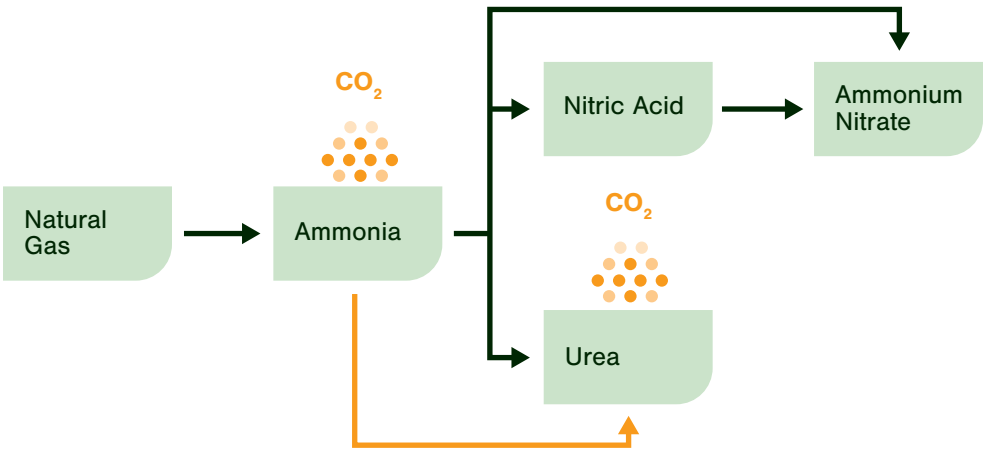
If there is an abundance of green ammonia, it will likely replace gas-based ammonia production. As a result, this will also eliminate production of urea since the carbon dioxide necessary for urea production will not be available anymore. This development will further enhance the production of ammonium nitrate-based fertilizers in Europe and will reintroduce these fertilizers in the US, Asia and Africa. There will be a large array of ammonium nitrate-based fertilizers to complement deficits in organic compost and manure-based fertilizer pellets.

Another factor that increases the attractiveness of nitrate production is that while hydrolysis of water provides the necessarily large amounts of hydrogen needed to fuel the world, it also produces large quantities of oxygen. This oxygen can be used to improve the production of nitric acid from ammonia, as an intermediate in the ammonium nitrate production process. In addition, oxygen fed into heating gas instead of air results in purer emissions, and using oxygen makes the traditional ammonia process fully suitable for carbon capture and storage.

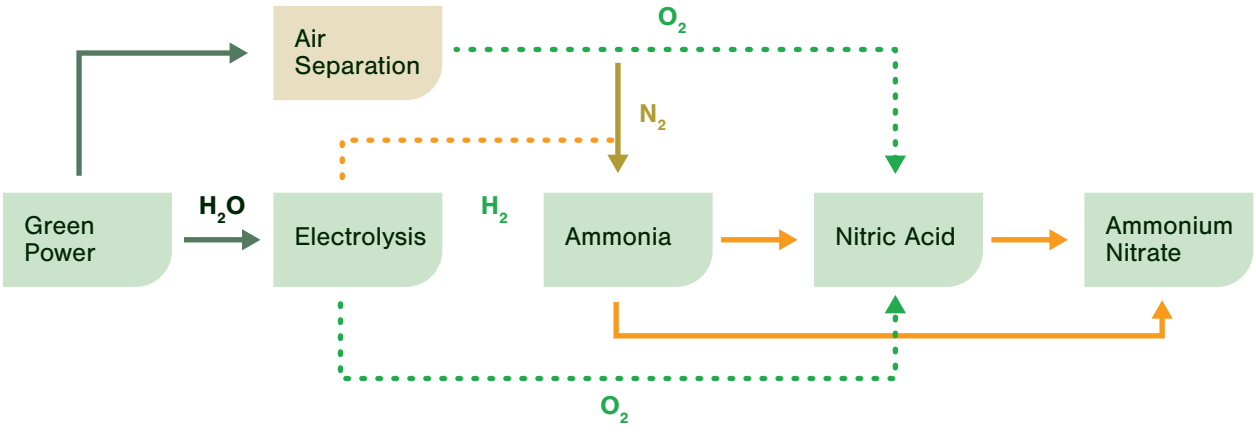
It is possible to imagine a situation in 2050 in which carbon neutral European production of fertilizers nourishes agricultural production, and the European fertilizer industry has become the most innovative and efficient in global terms, while reducing its carbon footprint to meet the EU's 2050 challenges. However, such a situation is conditional on an abundant amount of carbon-free and competitively priced electricity being available, and the expansion of networks for the transportation of ammonia/hydrogen.

The possible evolution of fertilizer production (2018 to 2050)

2018 Nitrogen fertilizer production (CO_2 emitted)



2050 Nitrogen fertilizer production (no CO_2 emissions)



4.

Main drivers towards 2030

Looking forward to 2030 it is possible to point to some key drivers that will shape the landscape for the fertilizer industry. All the usual influences on the business environment will be in play (economic growth, trade rules, currency exchange fluctuations etc). These are not examined here. Fertilizers Europe is focused on three factors of direct relevance to mineral fertilizers.

4.1. Information technology and data

Information Technology, data and knowledge will reshape agriculture over the next decade and more. It is clearly visible in what farmers are doing today, using for example: productivity records for farm production; automatic feeding; robotic milking; farm management systems (including fertilizer plans) and much more. Huge amounts of data are already collected, but not necessarily yet combined or fully utilised.

"Digital is the key enabler towards implementing sustainable and profitable farming practices on every farmer's field in Europe."

Terje Knutsen, Executive Vice-President Crop Nutrition, Yara International

Precision farming is the most talked about current development. It combines knowledge from various large datasets with Global Positioning System (GPS) information, with the possible use of drones, and potentially with self-driving tractors. These are developments that are bringing agriculture towards the ultimate goal of securing optimal growing condition for each individual plant. A major part of this will be the ability to combine immediate feedback from spectro-analysis with GPS so as to adjust fertilizer application continuously while, for example, a tractor moves over a field.

Obviously, much of this technology is expensive and so lends itself more to farmers, cooperatives or contractors working on bigger units. Given the trend in farm structure towards bigger farms/farmed units, new technologies will become an increasingly significant part of the future of farming.

Information technology could also play a major role in creating closer links between farmers and consumers. Supermarket buyers already insist on farmers having the ability to document several aspects of the products they sell (e.g. origin of inputs, livestock husbandry systems). In the future, blockchain technology will make it possible for a consumer to track the information on the product. Consumers will buy a loaf of bread and access information about where the wheat for the flour came from and how much fertilizer, and of what type, was used producing it. They will have information on the CO_2 emissions involved and of the overall sustainability of the product.

A major change will also come in the distribution sector. Agricultural inputs such as fertilizers and animal feed are traded and used in very large amounts. The supply of inputs to farmers traditionally relied on an extensive network of distributors, cooperatives and other actors. With bigger units, more specialised demand and information technology, the organisation of distribution in farming and agriculture will alter in a variety of ways.

4.2. Raw materials

Mineral fertilizers are produced from raw materials found in nature. Clearly those materials will not always be in unlimited supply. The fertilizer industry must address the challenge of potential scarcities of raw materials, which will occur for different reasons depending on the material concerned. This is also aligned with the EU's focus on moving to more renewable energy and a circular economy.

Nitrogen fertilizer is derived from ammonia produced from gas and nitrogen readily available in the air around us. Natural gas is abundantly available at present and in the foreseeable future, and so there is no immediate threat to ammonia production. However, there are other reasons - the need to diversify supplies, public pressure to reduce the use of fossil fuels for example - for the fertilizer industry to seek alternative raw materials and/or production methods (for example green ammonia from hydrogen).

In the case of phosphorus and potash, there are likewise no immediate threats to global supply, even if limits on physical supply will eventually be reached in the very distant future. The EU is already almost entirely dependent on imported phosphate rock with the only mining activity in Finland. However, high quality phosphate fertilizers will continue to being made in Europe in 2030. Provided raw material supply is not disrupted, the two current technologies - using phosphate rock directly, or using the rock to produce phosphoric acid - will still be in use and the efficiency of both processes will continue to be improved. Use of recycled waste material could, to a limited extent, replace some phosphate rock.

"To remain competitive in Europe, we need access to raw materials like gas and phosphate rock at the right price."

Duro Popijač, CEO, Petrokemija

Potash raw material comes to a large extent from European mining activity centered in Germany and with some located in Spain. On top of this, Europe imports potash mainly from Russia and Belarus. This import is to some extent offset by exports from European producers. Overall, the supply of potash in Europe should not pose major problems and processing of material into potash fertilizer in Europe will continue.

Nevertheless, the fertilizer industry needs to address the potential interruption of raw material supplies and prepare to find alternatives if possible. In some cases, this could involve major investments in new or adapted production facilities.

"As a big producer in a smaller Member State of the European Union, we depend on a well-functioning single market to export our quality products."

Darius Karpavičius, Director General, Achema

4.3. Science and innovation

Agriculture and horticulture continue to make scientific progress. Understanding plant growth and how to improve it has gradually led modern agriculture to where it is today. The last 10–15 years have seen very important advances in understanding plant genomics and the dawning of the age of digital farming has already led to much new knowledge being available, opening the way for new products and production processes.

But there is still much more to be discovered. One area of great interest is nitrogen fixation. This is the process by which nitrogen in the air is converted to ammonia, making nitrogen 'bioavailable' for living organisms to use as a fundamental building block for plant growth. Mineral nitrogen fertilizers are a technical way of achieving nitrogen fixing. Nitrogen-fixing bacteria are an area of future research and possible development. Another subject of interest is the rhizosphere - the area between plant roots and the surrounding soil. Understanding the natural processes taking place here has the potential to greatly improve nutrient uptake in plants and thereby the efficiency of agriculture and horticulture. If current research proves successful, this would have to be scaled up and tested more fully.

"In our Vision, modern fertilization equipment opens new opportunities for agriculture towards 2030. We observe already now that the practical experience with advanced equipment demonstrates potential for big economic and environmental benefits such as increased nutrient-use efficiency, more uniform crop and higher yields, just to name a few."

Wolfgang Hofmair, Manager Industry Relations, Borealis

Science will by 2030 have added new layers to our understanding of plants and how they grow. The use of big data will make this knowledge available in a practical form and so drive development of more differentiated and specialised fertilizer products and their application.

At the industrial level, while fertilizer production today uses tried and tested methods that have sustained the industry for many years, there are exciting new developments aimed at meeting longer-term challenges such as: more use of renewable energy; finding ways to use waste products from the fertilizer and other industries, thereby contributing to the circular economy. In specific terms researchers and private enterprises are working on projects related to: new catalysts; alternative methods of producing ammonia (e.g. from hydrogen using renewable electricity); ammonia storage and transport/distribution; energy saving; gas purification; emissions and waste management.

Recycling and integration of new waste streams in the production of fertilizers will be made easier with innovation and new technology.

5.

Developments related to fertilizer use

The main drivers for the future of fertilizer use and production of mineral fertilizers were highlighted in the previous chapter. In this chapter developments related to fertilizer use will be presented. Looking at trends surrounding farming has been an important building block for the Vision presented earlier.

5.1. The farming sector

The EU's farming sector is constantly changing. Over many years, the average size of farms has risen, and the number of farmers has fallen. At present the EU has 10.8 million farms with an average size of 16 ha. These average figures hide big differences between for example the Czech Republic's 26.000 farms with an average area of 133 ha, and Greece with 710.000 farms averaging 7 ha. The number of farms has been falling rapidly with more than 20% between 2007 and 2013. These figures however do not give the true view of the structure of the European farming sector as many of these farms are part-time or hobby farms, or several are farmed together in bigger units.

The statistics also show that the average European farmer is 51 years old with 31% of farmers older than 65 years and only 6% younger than 35. Also, behind these averages the differences between EU countries are big. 40% of Italian farmers are older than 65 while only 5% are younger than 35. In Austria the figures are 9% and 11% respectively. European farming is thus looking at a major generational change over the next 12 years.

This generational change comes with two distinct features: Young farmers tend to farm bigger farms and be better educated, according to official statistics. Thus, in the future an increasingly large proportion of European farming output will be the responsibility of well-trained and younger farmers operating larger enterprises.

Structural changes in EU agriculture will continue, however with a difference from past developments. There will be higher investments in technology, and in software, digital sensors, and specialist machinery.

This will further intensify the reduction in the labour force (though it will also perhaps increase the cost of labour per head as the workforce should become more highly skilled). It underlines the fact that farmers and growers are very focused on getting returns from significant new investments rather than continuing traditional practices.

"Our industry promotes the full lifecycle approach. We encourage farmers to use fertilizer application practices that are based on the right source, rate, time and place. Such an approach helps to reduce soil erosion, ammonia emissions and nitrification, as well as the amount of energy used in the farm production."

David Hopkins, Managing Director, CF Fertilisers UK Ltd

These structural developments are likely to affect the use of fertilizers in different ways. Farmers might not just demand fertilizer products; they might instead purchase a certain amount of 'photosynthetic conversion' from a supplier, meaning that the supplier will have to combine knowledge of soil, weather, crops and inputs like seeds, plant protection and fertilizers to get the right results, sometimes with the help of contractors with specialised machinery.

Attention to detail on the part of the supplier and farmer will have to be more acute - the focus on return on investment means that services to farmers and decision-support tools must become an essential element of fertilizer sales. Skills needed in the future, in addition to 'farming' expertise, will include: technological facility, legislative expertise, business management, innovation management, marketing, sustainability know-how, perhaps genetics and a minimum of knowledge of local ecosystems.

Contractors who provide specialised services to the farmer is one solution to the challenge of ensuring that farmers and growers have the means to apply the latest technology. Such contracting services already exist and there is evidence that their use is growing. It is clear that the proportion of farmers with training and expertise will rise; but contractors can be used where those skills and new equipment are not available.

5.2. Farming technology

Farmers in 2030 will rely increasingly on advice, planning and new tools and technology, with greater focus on nitrogen use efficiency, in order to produce sustainably and profitably.

Precision agriculture is a farming management concept using digital techniques, such as geo-referencing for object identification, measurement of specific parameters, Global Navigation Satellite Systems, connectivity, data storage and analysis, advisory systems, robotics and autonomous navigation to optimise agricultural processes. It can lead to improvement of the quantity and quality of agricultural output while using fewer inputs (water, energy, fertilizers, pesticides, etc.). The aim is to save costs, reduce environmental impact and produce more and better food. Precision agriculture is already present on farms across Europe, notably in arable, vegetable and dairy farming, but precision agriculture technologies will also be applied in other sectors.

The ability to combine real time data on plants with machinery has laid the groundwork for much more precise application of fertilizers according to need. For example, fertilizer companies are developing tractor-mounted sensors to detect an individual plant's nitrogen needs making it possible to adjust fertilizer application rates in real time. Water sensors to measure the appropriate fertilizer dosage to avoid affecting waterways will also become common. Specific fertilizers and application technologies such as fertigation and foliar spraying are increasingly targeted at individual crops to make the most productive use of both nutrients and water.

There will be more progress in precision agriculture development; its full potential has not yet been released. Machinery manufacturers are already establishing Cloud servers for farmers. These allow farmers to produce, analyse and act on data and to manage documentation. Driverless agricultural machinery may eventually be introduced.

As cities grow and expand, the physical and mental distance between cities and rural areas will also grow. On the other hand, this will stimulate an interest in city farming. Urban farming involves the employment of innovative techniques such as: growing plants in indoor environments; maximizing production, but with a smaller environmental footprint, by having multiple layers of plants; or combining plant growing with the use of organic waste from the urban environment. This will create a market for specialised and efficient fertilizers of a size to make it interesting for mineral fertilizer producers to supply.

There is a complementary relationship between mineral and organic fertilizers. Mineral fertilizers contain more concentrated, consistent and readily available nutrients than organic fertilizers and enable farmers to grow more on less land, but local organic fertilizers are also important for improving soil organic matter, and as a source of nutrients. Mineral fertilizers are furthermore important for ensuring the right balance of nutrients in the soil, for example to counterbalance the high phosphate content of organic fertilizers. It therefore makes sense for mineral fertilizers to be used in tandem with organic fertilizers.

"It is now commonly accepted that combining both mineral and organic fertilizer, scientifically known as integrated plant nutrient management, is what's best for both plants yields and healthy soils. To feed the world's growing population we need to maximise output on limited land. And the best way to do this is to use together mineral and organic fertilizers to create the right balance between NPK fertilizers."

Alexandros Giannikos, General Director, PFIC Ltd

Production of organic food in Europe is growing. This will not necessarily change the overall need for mineral fertilizers, since organic farming will take more of the manure, leaving conventional farmers to apply more mineral fertilizers. The organic farming sector also needs to supply nutrients to grow food and it needs to avoid nutrient 'mining' (whereby nutrients taken out of the soil by crops are not adequately replaced). The challenge for the mineral fertilizer industry will be to provide nutrients that meet the needs of organic farming, and the regulations that the organic sector works within. One example with clear environmental benefits is high quality and soluble mineral phosphate fertilizers which could replace some currently used low-solubility products such as phosphate rock.

Better understanding of nutrients will in general be an integral part of farm knowledge and advice, and the planning of nutrient application will become more formalised.

"European farmers have expanded their focus to food security, innovative plant nutrition solutions and environmental efficiency. To further support them, we have developed the Cool Farm Tool, a practical and intuitive online tool allowing farmers to better understand the environmental footprint of agricultural practices, while also enabling them to test fertilization management scenarios to optimise food production."

Terje Bakken, Head of Marketing and Sales, EuroChem

Parallel with this is the question of who will be advising farmers on nutrients: farmers' organisations, universities, semi-public bodies such as the agricultural chambers and the fertilizer industry itself will all be involved to different degrees. Knowledge will become a competitive factor in itself, and very important for the fertilizer industry's customer relationships.

5.3. Environmental regulation

In the EU application of nutrients, whether organic or mineral, will be tightly regulated. Future regulation will have a dual focus - on nutrient use efficiency, and on reducing surplus nutrient application, especially the use of nitrogen and phosphate.

New environmental regulation affecting the fertilizer sector might be expected in the following areas:

- Restrictions on the inclusion of some raw materials for fertilizer manufacture. Public concern over this, provided it has a sound scientific basis, cannot be ignored.
- Additional rules for on-farm storage and transport of fertilizers. All fertilizers, whether mineral or organic, need to be handled correctly and carefully.
- Fixed/stricter limits over total fertilizer application on farms or more likely the farm nutrient output – input balance.
- Limits on the timing of fertilizer applications, so they can only be used in the growing season.
- Programmes supporting reduced use of fertilizers in order to focus on e.g. biodiversity in certain nature areas.
- Promotion of and possibly obligatory farm level calculations of Nitrogen Use Efficiency.

Farmers and growers have recognised that there will be regulation of the use of fertilizers and other farm inputs. They also understand that this can be of long-term benefit to their businesses if the result is more efficient application of fertilizers.

"As an industry, we are committed to continue our efforts to support more efficient and environment-friendly production in Europe. We are doing a lot to reduce our CO_2 emissions and we have developed new technologies to deal with dust from our production. European farmers are offered products that reflect the most environmentally friendly production in the world."

Radomir Věk, Chief Operating Officer, Lovochemie

Addendum: Nitrogen Use Efficiency (NUE)

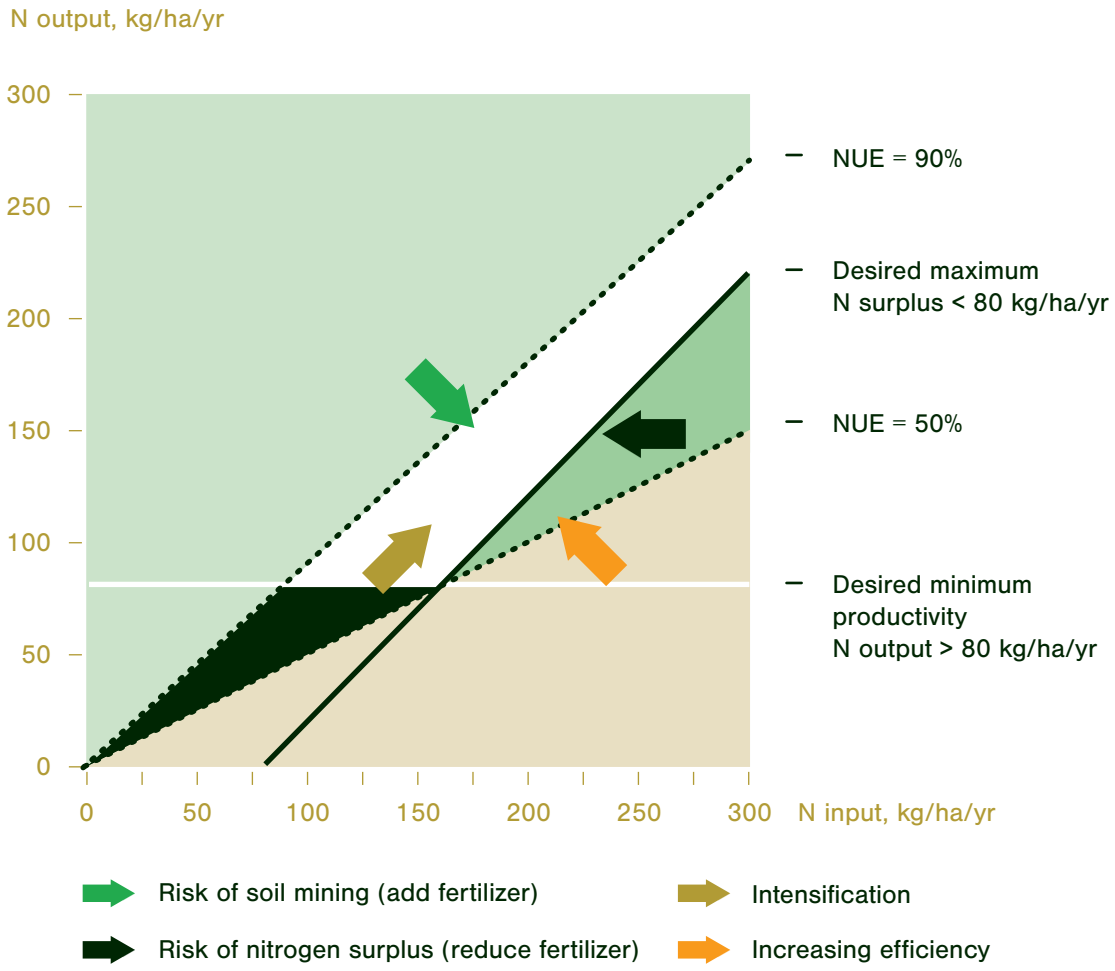
A long-term project of the EU mineral fertilizer industry has been to encourage the efficiency of fertilizer use in order to optimise plant growth and reduce environmental impact. In order to achieve this, Fertilizers Europe in 2014 initiated an EU Nitrogen Expert Panel (EUNEP) to address this issue.

EU Nitrogen Expert Panel (EUNEP)

- EUNEP brings together experts from different communities to work side-by-side. The majority of members come from a science background, but the panel also has members from EU institutions, industry and other stakeholders.
- EUNEP's main objective is to contribute to improving NUE in Europe, specifically to:
    1. communicate a vision on how to improve NUE in the food chain;
    2. generate new ideas and recommend effective proposals and solutions
- EUNEP's ambition is to improve nitrogen management through the use of an indicator for NUE applicable to agricultural production and food production/consumption systems.

EU Nitrogen Expert Panel has published an indicator for the efficient utilisation of nitrogen in farming (and eventually within the entire food system). The indicator can show how different strategies can contribute towards improving NUE, depending on the starting situation. In some contexts, the main drive may be to increase food production; in other contexts, the priority may be to protect soil and habitats from nutrient losses. The NUE indicator is applicable at different scales, from farms to countries, just as it can be used to evaluate the efficiency of the food chain as a whole.

Illustration of an NUE indicator



Source: EU Nitrogen Expert Panel, Nitrogen Use Efficiency (NUE), 2015

Illustration of NUE indicator, a two-dimensional N input - N output diagram. Typical reference value for arable farming is NUE 50-90% represented by two dotted lines. The horizontal white line adds a minimum desired N yield level, in this case 80 kg/ha, while the diagonal solid black line adds the constraint of a maximum N surplus set at 80 kg/ha. Combining all these elements gives the desired range of NUE values (the white space) which represents the target area where the efficient and environmentally conscious farmer should be.

The four arrows show how different strategies can contribute toward improving N use efficiency, depending on the starting situation. According to context, both intensification and extensification strategies may contribute. In some contexts the main drive may be to increase food production and resource use efficiency, in other contexts the priority may be to protect soil from over-fertilization.

6.

Developments related to fertilizer production

As was the case for farming and fertilizer use, developments related to fertilizer production will be presented in this chapter. These trends are equally important building blocks for the vision presented earlier.

6.1. Continuous improvements

The European fertilizer industry is in a position where no production breakthroughs are expected in the short-term. Nevertheless, there are still developments taking place in a process of continuous improvement.

For example, energy efficiency in nitrogen production has been significantly improved since the beginning of the 20th century. Modern fertilizer factories are now close to the theoretical minimum of energy consumption when producing ammonia – the first step in the production of nitrogen fertilizer.

"We are putting a lot of effort into excelling in every aspect of our daily operations. We recognise the need for continuous improvement in our installations, including it in our Vision towards sustainability."

Theodora Kouloura, Deputy Plant Director, New Karvali Fertilisers S.A.

The first building block for the whole nitrogen fertilizer industry is ammonia. In Europe, ammonia production is mainly based on natural gas as a raw material and steam methane reforming (SMR) as the main technology. The first step involves splitting the natural gas molecules with the help of steam and high temperatures, to obtain hydrogen and CO_2. In a second step, this hydrogen is then combined with nitrogen from air to produce ammonia. Although it is the least carbon-intensive of the technologies available today, SMR nevertheless generates large quantities of CO_2.

Some of this CO_2 is already used by the industry (carbon capture and use) to produce other chemicals such as melamine and calcium carbonate. CO_2 is also used in other industries, for example in carbonated drinks, while the remainder might be released into the air or permanently stored underground (Carbon Capture and Storage).

"If you ask me for the three main building blocks of the European fertilizer industry in 2030, I believe they will be resource efficiency, industrial symbiosis and competitiveness, and everything we do will reflect this."

Mihai Anitei, CEO, Azomures

While the basic process of fertilizer production (the Haber-Bosch process) has not changed for many years, companies have improved their equipment and control systems and have better training systems to improve their employees' skill levels. As a result, European fertilizer producers can boast of having the worlds' highest energy efficiency in production and also the lowest environmental footprint. These production values will need to be improved further in the coming years, not least as a result of the pressure likely to come from society leading to new targets for environmental performance improvements. The introduction of natural gas as a feedstock, and better catalysts, has made ammonia production much more energy efficient. While further improvement takes place continuously, the technology is approaching the theoretical limit for energy efficiency, making each further step more challenging and costlier.

6.2. Decarbonisation of energy

The EU has decided to be at the forefront of the fight against climate change and is already taking strong action. The EU fertilizer industry is subject to a carbon cost via the Emissions Trading Scheme (ETS). The industry is almost unique, globally, in facing this cost. And the EU has just agreed an even more challenging 2030 framework for climate and energy policies. This includes a 40% cut in greenhouse gas emissions from 1990 levels and a 32% binding renewable energy target for the EU. In the longer term, the EU will continue its switch towards a net zero emission economy. It is committed to reducing GHG emissions by at least 80% below 1990 levels by 2050, and is currently elaborating plans - due for publication by end-2018 - for further decarbonisation.

"I am proud that as an industry we demonstrated a strong commitment to improve environmental performance by reducing GHG emissions over 40% compared to 1990. As a result, European producers are capable to provide customers with products that have the lowest environmental footprint in the world."

Jarosław Ptaszyński, Member of the Management Board, Anwil

The fertilizer industry is already affected by the EU ETS. Further decarbonisation will affect the industry in multiple ways, exposing it to the risk of carbon leakage (whereby industries move production from high to lower-regulated regions). However, provided that systems are put in place for maintaining a level playing field, the EU ammonia industry can become an important actor in the low carbon transition ahead and become a key player in the energy storage that will certainly be a fast-growing sector. Storing energy and transporting it as ammonia is the cheapest, easiest and safest low carbon alternative.

"Our industry's Vision is ambitious, requiring contribution from all stakeholders. We therefore ask the EU to place an industrial policy on top of its agenda. A coherent EU regulatory framework – covering energy, industrial, climate, trade and environmental policies – is a necessary condition to ensure a global level playing field. New policies should make it possible to be a producer and to contribute to the EU economy as well as to create high-skilled and well-paid jobs."

Paweł Łapiński, Vice-President of the Management Board, Grupa Azoty

Given that the life span of large-scale European ammonia plants is at least 40 years, neither the dominance of gas as a raw material nor SMR technology is expected to change significantly by 2030. However, part of the gas used can be biogas, thus reducing the carbon footprint of the industry.

By 2030 carbon capture and storage (CCS) will have become a reality in some parts of Europe. This means that the CO_2 from ammonia production that is not used for industrial purposes can be permanently stored underground and not released into the atmosphere. This type of climate-friendly ammonia production combining SMR and CCS, known as 'blue' ammonia, could represent 5% to 10% of EU production by 2030.

"As an industry, we do realize that the EU has to reduce its emissions. At the same time, the system must be in line with economic and technological reality to let us, European fertilizer industry, stay competitive and to continue to grow and provide jobs. We have some of the most efficient plants in Europe so we should not be punished."

János Szilágyi, CEO, Nitrogénmuvek

An even more climate friendly way of producing the hydrogen necessary for ammonia is through electrolysis. If renewable electricity is used to split water molecules by applying electricity then the process can be practically carbon-free. This is known as 'green' ammonia. In the decarbonised economy of the future, 'green' ammonia has another very important role to play - it is the safest and most efficient long-term energy storage method. When excess renewable electricity is available, it can be turned into hydrogen and then ammonia and easily stored.

"I am confident that, under the right circumstances, already in 2030 part of the ammonia production will take place with sustainable sources of hydrogen."

Gert Jan de Geus, CEO, OCI Nitrogen

By 2030 'green' ammonia, either for producing green fertilizers or as energy storage, will still be relatively insignificant in terms of volumes unless there is an economic or other imperative that accelerates moves in this direction. Perhaps only 10% of ammonia will be produced either by electrolysis or based on renewable gas by 2030. Government action can help; by 2030 the public sector may, through support and regulation, reward ammonia production facilities for the role they play in this.

6.3. Circular economy

The circular economy is about reducing waste and protecting the environment, but it can also create economic opportunities and competitive advantages. The EU mineral fertilizers industry welcomes the circular economy initiative as the industry has always been 'circular'. Since the beginning of the industry, by-products from one production process have been used as raw materials for making fertilizers. The industry thus has a potential strategic advantage in this area.

"As a European fertilizer industry, we are proud to lead the way towards a fully circular economy. Already today synergies between fertilizer producers and industries such as nylon producers allow taking at least 10 million tonnes of ammonium sulphate and sulphur and converting that into basic fertilizers. We expect that by 2030, with the right policy framework, industrial symbiosis will be pushed even further."

Christoph Gahn, Vice President Polyamides and Precursors, BASF

The EU mineral fertilizers industry already recycles millions of tonnes of materials from other industries. Some concrete examples of the place of the fertilizer industry in the circular economy are:

- It uses ammonium sulphate that is a by-product from nylon production in making sulphate-containing mineral fertilizers. Ammonium sulphate used by the EU fertilizer industry represents more than five million tonnes per year.

- It takes sulphur from oil and gas refining to make sulphuric acid (used in fertilizer production). More than five million tonnes of sulphur per year are used by the EU fertilizer industry.

- It applies used acids to dissolve rock phosphates in the production of phosphate fertilizers.

- It transfers residual heat and CO_2 from ammonia operations within fertilizer manufacture to neighbouring glasshouses for use in horticulture, helping those growers and reducing industrial emissions at the same time.

- Part of the CO_2 produced by the mineral fertilizer industry is purified and sold for use in food and beverages, such as sparkling water and in cleaning products.

By 2030 it will be clear that the fertilizer industry is a key industry in the circular economy as it continues to engage in industrial symbiosis and make use of industrial by-products from other industries such as the petrochemical industry. An example will be the integration of the fertilizer industry with facilities for communal waste water treatment and for mono-incineration of waste. The fertilizer industry will be able to use the by-products of those facilities through technologies guaranteeing a clean and risk-free product for further use as raw material in fertilizer production. The main limitation on this development may be lack of investment by local authorities and others. It is therefore expected that the phosphate industry will only recycle phosphate from approximately 10 % of communal waste water treatment plants by 2030, unless the economic or regulatory parameters change.

Given its in-depth knowledge of industrial processes and nutrient management, the EU fertilizer industry has a key role in closing the nutrient loops and is in fact an indispensable actor of the circular economy.

6.4. New products

The EU fertilizer industry is developing new products to suit farmers' and growers' needs, and also to fit the industry's business and regulatory environment. The trend to provide products with characteristics better suited to single crops or specific locations and growing conditions will deepen in future. Tailor-made combinations of macro and micro nutrient mixtures aimed at growing crops more efficiently will become the norm, as well as products combining nutrients, inhibitors (allow fertilisation with significantly reduced emissions) and bio-stimulants.

"We expect the demand for more balanced fertilizers containing macro and micro nutrient that can be better suited to a single crop/a specific situation will deepen. Tailor-made combinations will become common and will improve yield quantity and quality together with reduced influence of losing nutrient to the environment. The tailor-made fertilizers will play increasingly important role towards 2030, as such products can cater more precisely to the demands of farmers and growers."

Aviv Bar Tal, Vice President Marketing & Sales Europe, ICL

Due to a much more demanding farming sector, EU fertilizer companies' product range, including different NPKs and mixtures of micro-nutrients, will be significantly expanded. It will be possible to capture the value of the products used, and thus quality products will carry a premium corresponding to their role in aiding yield improvement and enhancement of the quality of the crops concerned.

The market for such products will grow significantly in importance towards 2030 as they can cater more precisely to the demands of farmers and growers. For example, biodegradable coatings can be applied to fertilizer granules to control the rate of nutrient release in soil, thus offering multiple environmental, economic, and yield benefits (typically in the glasshouse sector). A new generation of controlled-release fertilizers coated with biodegradable polymers will have matured in 2030 opening up new possibilities.

Looking further to the future, researchers in both the public and private sectors are active in the area of increasing nutrient uptake by plants. For example, the multiplication of naturally occurring soil-borne microbes could find a place in the fertilizer market. When applied to the soil as such or combined with mineral fertilizers, the microbes interacts with the plant root system to increase the productive capacity of both the soil and the plant. While products based on this type of research may appear a long way off, significant funds are being put into this type of research globally.

7.

From vision to reality

From its position at the crossroads between nutrition and energy the European mineral fertilizer industry can contribute positively to European society in 2030 under the right framework conditions.

The Vision outlined and discussed in this report lays the foundation for a constructive dialogue with the EU institutions, Member States, farmer representatives and other key stakeholders on the future of fertilizer industry in Europe. The dialogue should go beyond fertilizers, to include how this industry can contribute to wider EU society in the lead up to 2030.

As the EU voices its ambition to be the frontrunner in sustainable agricultural production, the European mineral fertilizer industry commits to contribute to this objective by playing a key role in the food production chain, providing innovative plant nutrition solutions that will help European farmers meet future food needs in a sustainable way.

The European mineral fertilizer industry will also continue to provide added value and to secure jobs at its many different production sites spread over Europe, thereby contributing positively to the EU economy. At the same time, it is clear that the limited availability of raw materials in Europe, and high gas prices, undermines the competitiveness of European producers. This is a huge challenge.

The EU is also forging ahead with a policy to decarbonise the economy. The European mineral fertilizer industry is based on the use of natural gas and today operates the world's most energy efficient fertilizer production facilities. From a global climate perspective, each tonne of production in Europe saves global CO_2 emissions. But the industry can do more. Above all, it can perform in the long run a key function in making the hydrogen economy function in practice.

In order to deliver on its Vision, the European mineral fertilizer industry call for a policy framework which will enable the industry to continue to excel in both use and production of fertilizers while maintaining its competitiveness internationally.

More specifically:

Ensuring a level-playing field

European mineral fertilizer producers operate in a global market as fertilizers are traded in large amounts between continents and across borders. Ensuring a level playing field on fertilizer, energy and carbon cost must be the first priority.

As the largest industry sector consumer of natural gas, the EU nitrogen fertilizer industry's competitiveness is predominantly driven by affordable and fair gas prices. Given that typically 60% to 80% of production costs are natural gas costs, it is vital that that the EU addresses the industry's competition concerns and enables the free flow of gas at competitive prices in European gas markets. Strong enforcement of EU competition rules, well-targeted European and local energy legislation and its consistent implementation are vital in order to achieve this objective.

A reformed WTO should include an agreement on energy outlawing unfair state price fixing and subsidisation, dual-pricing and other forms of harmful discriminatory pricing.

In relation to the EU's own correction of unfair trade, it is imperative that the EU institutions continue to develop effective and efficient trade defence instruments able to correct structurally distorted gas prices and the risk of injurious dumping from competing countries. As EU industry will face ever stringent requirements in relation to fertilizer production and carbon cost, the EU authorities must develop mechanisms to ensure a level playing field with regards to these factors. Focusing only on tariff reductions is not enough.

Supporting knowledge build-up in European agriculture

Mineral fertilizers are integral to modern agriculture: they provide farmers with the means to meet increasing global food and energy needs. Knowledge of optimal fertilizer use combined with close collaboration with the farming community and the entire food chain is needed to maximise nutrient-use efficiency and reduce the footprint of food production.

Policies, such as the Common Agriculture Policy (CAP), should foster good nutrient management and incentivise farmers to increase the nitrogen use efficiency, which at the same time increases yields, improves quality and reduces the potential environmental impact. It is also a concrete step towards improving incomes of farmers and the rural environment in general.

Enabling transition to a decarbonised economy

The EU has the aspiration of leading the world in addressing the global climate change challenge and is currently looking at cost-effective ways to decarbonise the economy.

As renewable energy and hydrogen are to play an increasingly important role in powering the EU economy, ammonia should be regarded as an important way to store and transport hydrogen in energy systems with a high penetration of renewables. It is essential that policies include ammonia in decarbonisation efforts, through support for research and pilot projects plus implementation of the necessary standards for energy pipes and transportation.

Underpinning the Circular Economy

The fertilizer industry is already recycling a wide range of by-products and uses surplus energy and raw materials that derive from other production processes on fertilizer production sites, as well as from production processes taking place in other sectors. However, the full potential of the circular economy and industrial symbiosis is far from being reached. New policies and R&D programmes should incentivise further industrial symbiosis, and promote circular thinking, to ensure further optimisation of resource use, closing material loops and as a result minimising environmental impacts.

At the same time full attention should be paid to the regulatory and economic aspects of recycling, so that the right conditions for producing quality products are promoted.

Including practical applications in Research, Development & Innovation programmes

From the fertilizer use perspective, incentives and support to foster innovation in agriculture represent an essential factor in supporting both environmental performance and the competitiveness of the farming sector. Better access to more practical research should be generated by the CAP for all the actors in the food supply chain including input industries such as fertilizers and the research programmes should also support implementation and demonstration projects.

From the fertilizer production perspective, ensuring the competitiveness of not only new but also established industry in Europe has to remain a priority for EU decision-makers. Industry should benefit from innovation programmes and programmes that support up-scaling and pilot-testing coming technologies as this is the only way to create a successful economy moving towards a competitive low carbon economy and a sustainable agriculture in Europe.

Committing to an integrated EU industrial policy

The European Commission, the European Parliament and Member States must commit to a new and ambitious industrial strategy for energy intensive industries. The main policy objective should be to create an attractive environment for investment, in this way laying the foundations of future competitiveness and prosperity. Policy initiatives should make it easier to be a producer, to contribute to the EU economy and to provide and safeguard sustainable jobs. Such an approach will help the domestic industry to contribute to the long-term EU objective of moving towards a modern, clean and competitive economy.

8. Interviews

A young farmer perspective

Iris Bouwers

Iris Bouwers is Vice President of CEJA (the organisation representing young farmers in the EU). The Bouwers have a family farm in the Netherlands, with mixed livestock and arable production, growing a variety of field crops.

Ms Bouwers uses both mineral and organic fertilizers on her farm. All the farm's own manure is used and dairy slurry is brought in from a local farm. The soil is sandy so significant fertilizer quantities are required in order to maintain, let alone increase, yields.

Fertilizers are normally bought through a cooperative where all inputs are purchased and produce (e.g. onions and grains) sold. Ms Bouwers foresees a situation where fertilizer raw materials could be in short supply in future (e.g. if there is a problem with supplies from Morocco) which will encourage more efficient fertilizer use.

Iris takes soil samples every four years; leaf samples are taken every year. The results, coming from lab analysis, are the main source of information on fertilizing. There are not many options for advice and farmers need such advice to be low-cost and reliable (and relatively simple).

Farmers in the Netherlands are not currently under strong pressure over fertilizer use, though consumers scrutinise farming in general, and intensive farming and glyphosate use in particular. Concerns about climate change do put pressure on farming. However, this is not currently aimed at fertilizer use.

Many farmers are concerned about the circular economy and are already trying to farm sustainably.

Food consumption patterns will change, though slowly (evolution not revolution). Farmers are ready to adapt production to meet changing demand. Farmers need to be as transparent as possible about production methods. Farmers will respond if demand for organic foods grows. Organic farming is becoming more professional. But the world cannot be fed with organic food alone.

Farmers should be interested in what research can deliver for farmers in the form of electronic tools. The R&D sector needs to disseminate the science and educate farmers. Younger farmers are ready to learn. Farmers need to be motivated to know as much as possible, especially about soil quality. Farmers should also be more involved in nutrient management.

Precision farming works on bigger farms, but the benefits of robotics and self-driving tractors are uncertain. The biggest driver for more precision farming will be fertilizer cost; farm revenues should improve with more efficient fertilizer use.

A research community view

Achim Dobermann, Rothamsted Research

Dr Dobermann is Director and Chief Executive, Rothamsted Research (UK), a leading global research centre focused on strategic agricultural science to the benefit of farmers and society.

Rothamsted does much work in soil science, which has implications for nutrients. For example, new methods for assessing soil could lead to a new paradigm for soil testing. Some work into how to make phosphate production more efficient, using accumulated residual phosphates, is being undertaken.

European fertilizer use will be affected by pressure to improve the sustainability (economic and environmental) of agricultural production, for example by recycling more.

There is some concern that the EU fertilizer industry puts very little into Research & Development (R&D). Overall the industry spends less than 1% of its total revenues on R&D.

There appears to be very slow growth in precision farming, despite high hopes – it is not yet profitable enough. It's an area of great potential but the benefits are not yet demonstrable.

There should be more funding of R&D in the area of precision farming, to find whole management solutions, not just new technologies. There is a need to get engineers and soil scientists to work together.

Solutions that are too complex won't be used by older farmers. So simple management solutions are needed, including software.

One particular area for research could be finding a new paradigm for making fertilizer recommendations, and interpretation of results in relation to crop responses and fertilizer recommendations. At present soil analysis is inaccurate and hasn't changed for many years.

The major weakness of the fertilizer industry is in the algorithms used to translate data, for example to steer decisions on how much fertilizer to apply.

In 10 years' time there will be a whole new way of doing this using faster spectro-analysis, even in the field. Then there will have to be more emphasis on diversified nutrient requirements.

It is difficult to envisage a scenario in which fertilizer use will rise. It is more likely to go into slow decline.

Some researchers are sceptical about automation. There have been no massive advances, just many prototypes. And the public is a bit scared about Artificial Intelligence. Automation is necessary, for there to be smaller, more agile machinery.

Research Institute solutions

Janusz Igras and Krzysztof Borowik, INS (Poland)

Professor Janusz Igras is General Director of the New Chemical Syntheses Institute (INS), a Polish state-owned scientific and research institute. **Dr Krzysztof Borowik** is Deputy Manager of the Fertilizer Department. INS operates in many fertilizer areas, covering both fertilizer products and industrial production methods.

Climate change and growing demand for food are major challenges facing this industry. In 2018 in Poland four million hectares of arable land were drought-affected, resulting in financial losses of €800 million plus. INS policy reflects these problems, for example aiming to develop energy-saving technologies, working to reduce greenhouse gas emissions from fertilizer and agricultural production, developing fertilizers that increase plant resistance to water stress. It may be possible in the future to grow thermophilic plants (adapted to high temperature) in northern European countries. Droughts will have an equally important impact on the type of crops grown. It will thus be necessary to increase efficiency through precise fertilization, the use of controlled release fertilizers and of fertigation and soil liming.

INS conducts research related to the production of a new type of fertilizers, with increased operational efficiency, based on various types of raw materials, including management of waste materials. This reflects Poland's plans to increase the use of fertilizers with enhanced efficiency and to reduce negative impacts on the natural environment. Examples of these are urea stabilised with the addition of urease inhibitors and fertilizers containing nitrification inhibitors.

INS has many years of experience working with fertilizer manufacturers, especially in the field of nitrogen industry technology. The work includes: synthesis gas production and purification; high purity hydrogen production; modernisation of ammonia synthesis plants; reducing consumption of energy and hydrogen; design and updating of nitric acid installations, and of ammonia oxidation units (catalytic reduction of N_2O); development and production of new industrial catalysts.

INS conducts research on fertilizer application, for example using soil-friendly microorganisms, amino acids, fertilizers with slow release of nutrients and improved mechanical properties in products. INS research into the production of bio-fertilizers using strains of soil bacteria to help release nutrients to plants aims to develop high-performance products. However, this is not expected to completely replace synthetic nitrogen compounds with natural sources.

Production of hydrogen needed for ammonia production in Poland is currently based on natural gas. Alternative hydrogen sources are interesting scientifically, but generation of the required quantity of hydrogen from renewable energy would require huge investments and would pose other challenges regarding production, transmission and storage. Another possibility investigated by INS is the production of hydrogen using thermal energy from nuclear reactors but its feasibility is questionable.

An environmental NGO perspective

Andrea Kohl, WWF

Andrea Kohl is the Programme Director of the World Wildlife Fund's European Policy Office in Brussels. WWF's main interest is in sustainable agriculture and the overall food chain.

Across the many countries where it is present, WWF continues to see serious environmental impacts related to nutrient management in agriculture (e.g. in Poland and the Baltic States over eutrophication, in Germany over soil health/ quality and nitrates, in North-West Europe with over concentration of livestock farms).

WWF believes that innovating and optimising fertilization practices, with the appropriate use of available technology and strong advisory services, can lead to reducing nitrogen use on farms and associated environmental impacts such as nutrient run-off and greenhouse gas emissions.

WWF shares the view that the fertilizer industry should move towards a future where fertilizers deliver more precise nutrition (applying more knowledge per hectare). Realistically this will be more likely to apply mainly to bigger farmers. WWF suggests further exploring what could be done to bring along smaller farmers – for example by using field services and enhanced advice.

However, the final nutrition of plants and adequate nutrient management depends on living soils. Therefore the development of functional and diverse soils has to be at the centre of attention of any agricultural activity. In this regard, WWF would like the fertilizer industry to adapt its current core business model and to focus on greater sustainability.

By 2030, the EU needs to be far more sustainable, with a strong shift to more agro-ecological approaches in farming, and also with consumers changing eating habits towards more plant-based food, as WWF has long been encouraging with the LiveWell project.

Sourcing food locally and from sustainable and organic sources is a part of this move, but structural changes such as the diminution and de-concentration of livestock production, and the reintegration of crop and animal agriculture for the benefit of living soils and plant nutrition, are needed.

WWF works with allies at EU level. WWF would like to see more cross-sector cooperation, in the common interest, in areas such as enhanced sustainability, nature protection and climate change mitigation in agriculture.

Farming in South-East Europe

Valentin Marginean, Romanian farmer

Valentin Marginean farms 1.400 mainly arable hectares of grains, corn, rape, sunflowers and soya. He raises a few animals for domestic consumption, including some grazed sheep.

Valentin (Vali) uses only mineral fertilizers. The whole farm is fertilized ("there is no part of the farm with no fertilizer"). He has a fertilizer plan for the farm.

Vali purchases fertilizers from a local agro-supply group (a private company; Romania does not have many cooperatives). The company also provides agronomic advice. Where it cannot provide the right advice Vali goes to his fertilizer supplier.

Most Romanian farmers are responsible users, however their ability to do so decreases with smaller farm units, especially in poorer farmer-dense regions. There is no real pressure on farmers regarding the quantity of fertilizers they use – it is not an issue.

Vali's main concern is to improve the farm's productivity and overall output. Vali does not see how the world could feed itself using only organic food/production techniques.

For Vali climate change is a somewhat academic question – he is more worried about day-to-day economic factors and the condition of his soils. The pressures he faces are more economic, about maximising production, yields and efficiency.

Vali is concerned that pressures elsewhere in the EU might lead to, for example, lower limits on fertilizer applications per hectare. Romanian farmers use, on average, three times less active ingredients than the EU average. Romanian farmers would like to be able to use more. If there is strong demand for greater crop yields in future farmers need to be ready to respond. They should be ready to increase fertilizer dosages.

Vali believes fertilizer producers should give more advice in future on know-how.

He believes machinery developments will bring added value to farmers. He has gradually adopted new techniques over the last 10 years or more. He can cope with new technology as he is well trained. Most big farmers are in the same position. However many farmers, especially small farmers, need government help with training in the use of new technology. Distributors and farmers should share the cost of improving farmers' knowledge and ability to purchase new technologies.

The view from a technology provider

Svend Erik Nielsen, Haldor Topsoe

Svend-Erik Nielsen is Fellow and Senior Proposal Manager at Danish company Haldor Topsoe. The company's main role in the fertilizer sector is to offer licence, catalyst and process designs for ammonia plants, with various connected services enabling plant owners to optimise output, and reduce energy consumption and emissions.

In Topsoe's view the existing gas-based ammonia production process is unlikely to be replaced by another in the short-term. Topsoe thus continues to concentrate on making incremental improvements in all steps of the ammonia process – trying to make each step and catalyst more efficient.

Rising concern about the environment/sustainability/climate change is a major driving force for the fertilizers industry, especially CO_2 emissions legislation, and Topsoe sees a drive for greater use of renewable energy sources/reductions in fossil fuel use. The traditional way of producing ammonia is under some pressure.

With this in mind, Topsoe has long been working on development of the next generation of the ammonia process. Electricity is one of the alternative energy sources being examined. However, under current economic circumstances the cost is too high compared to fossil energy. Topsoe believes the economics of renewable energy will change gradually over time, and thereby change the preferred process.

Topsoe has recently introduced a new ammonia process, SynCOR AmmoniaTM, in which the reformer furnace that consumes a lot of fossil energy has been eliminated. The new process is more efficient and environmentally-friendly and, in addition to being safer due to increased automation, it also consumes less natural gas and significantly less water than the current process.

In the longer-term the fertilizer industry should aim not only to reduce the amount of energy consumed and CO_2 emissions created, but to change to use more sustainable energy sources, and produce ammonia from hydrogen and nitrogen generated from sustainable energy rather than from fossil energy. For the medium-term, Haldor Topsoe has new technology available, and is ready to help existing fertilizer manufacturers to revamp their plants, first by moving to more electricity use in parallel with gas and then gradually moving to more and more electricity use.

Eventually Topsoe foresees ammonia being produced from nitrogen (in the air) and hydrogen (in water). At present the technology to do this is too expensive and the quality results not good enough. However, regulation/taxation could change this picture in the future, and Topsoe believes that its portfolio is well prepared to meet the future.

Haldor Topsoe is prepared to assist the fertilizer industry in meeting future, new societal/political developments both through revamping of existing facilities and in new plants.

An academic view

Oene Oenama, Wageningen University

Oene Oenema is Professor in Nutrient Management and Soil Fertility at Wageningen University (the Netherlands), which focuses on healthy food and the living environment.

Wageningen University has an interest in the consequences of nutrient use (whether manure, waste, fertilizers or other), and also in whether there are sufficient nutrients available in the future in accessible form.

There is little core funding for fertilizer research (only for research into the mitigation of nutrient loss and enhancing Nitrogen Use Efficiency - NUE). The fertilizer industry spends less than 1% of its turnover on research.

The fertilizer industry has some options to consider in relation to improving the sustainability of fertilizer use, for example:

- Storing more carbon in the soil (nitrogen is needed for this)
- Enhanced efficiency fertilizers that also reduce nitrogen oxide (N_2O) emissions

Climate change and the Circular Economy are the two drivers most likely to bring change to the fertilizers industry in Europe by 2030.

Dutch farmers have the knowledge to use modern technology. Their problem is lack of time, so they outsource activities. Contractors are increasingly involved but machines are becoming too big, causing problems such as soil compaction.

The industry should move towards a future where fertilizers deliver more precise nutrition (applying more knowledge per hectare, better balance of all plant nutrient elements, interactive web-based tools). The big question is whether these tools are cost-effective.

Some companies are likely to take a lead in things like manure nutrient and sewage nutrient recycling, and food waste reduction because current societal and industry practices are unsustainable in the long term. But to become more involved in nutrient recycling the industry will have to look beyond the primary nutrients. For example, the industry could look at the options for including the ash from sewage incineration in fertilizers. Primary rock phosphate can be mixed with secondary waste resources such as treated sewage sludge. This fits with the EU's Circular Economy initiative.

Regarding the NUE effort, the development of nutrient efficiency plans aims to help farmers adopt NUE in order to improve their profitability. Indicators could show where nutrient waste takes place, but also show other insights of benefit to farmers (in the end farmers should be able to calculate their own NUE, but they will need advice on what the indicators mean and how they should change practices).

Whatever results from the NUE exercise, it has to be kept simple. Eventually the NUE work could lead to the development of a NUE tool linked to the Cool Farm Tool. NUE helps the environment generally, with implications for fertilizers specifically.

Farm machinery in 2030

Peter Pickel, John Deere

Dr Pickel is Manager External Relations for John Deere in Germany. John Deere produces agricultural machinery, such as tractors, harvesters, planting, seeding and tillage equipment, and precision agriculture and other technology solutions.

John Deere is involved in an award-winning nutrient management system used for the precise application of organic or mineral fertilizers, using sensors. The system allows a holistic view from harvest to harvest and includes technologies that provide very precise fertilizer application.

Deere is very involved in the development of sensors. One spreader-mounted application measures the ingredients within slurry so that the data can later be analysed and areas of fields (or in future individual plants) that need more or less subsequent fertiliser applications can be identified.

Deere, like its competitors, is also hoping to develop machinery that can provide 'single plant treatment'. Seeds could be treated allowing an individual plant to be monitored from seed to harvest. This is already possible with sugar beet and potatoes (and some fruits). The application of nutrients can then be geared to the individual plant's exact needs.

Deere believes that the 'internet of things' provides many opportunities for farming. Deere aims to allow farmers to manage the whole plant nutrient system. In his view the EU market is suitable for precision machines.

Deere, like other machinery manufacturers, is establishing Cloud servers for farmers. These allow farmers to produce, analyse and act on data and to manage documentation. There are several systems already on the market.

Another main area of development is in automated vehicles/machines. The technology for driverless tractors exists but society is not ready yet. Once driverless transport is accepted, agricultural machinery may then follow road vehicles into use.

At the technical level the biggest problem with this is the difficulty of achieving functional stability in farm machinery. In a factory machinery can work very smoothly with few breakdowns and hold-ups. In a farm setting this is more difficult to achieve.

Ongoing urbanisation in many EU countries is reducing the available workforce. And, farm structures are betting bigger, more sophisticated technically and more professional. Like the rest of society, farmers are moving towards more automation. However, there is a major impediment – lack of reliable 5G coverage in rural areas. In addition, farmers need to be very highly trained, as do machinery sales/after-sales staff.

Advisors' advice

Kristoffer Piil and Leif Knudsen, SEGES

Mr Piil is Senior specialist, focusing on environmental issues at SEGES (an independent Danish body providing, inter alia, specialist advisory services, IT programmes).

Mr Knudsen is an agronomist and team manager. SEGES manages development and service functions for farmer-owned advisory company.

SEGES is farmer-owned. However, it works very closely with the fertilizer industry in Denmark also, and liaises with the fertilizer distribution chain (with both cooperatives – the major players - and private distributors). Of the 1.000 field trials SEGES conducts each year around 200 relate to fertilizers. All results are made available publicly.

Farmers are encouraged, in a scheme started in 2017, to submit the results of their own on-farm trials.

Fertilizer use in Denmark is tightly-controlled. Farmers are allowed to use fertilizers up to a maximum amount per hectare (varying according to the crop concerned). SEGES advises farmers on how to maximise returns within the limits imposed, while meeting environmental stipulations.

Environmental pressures on farming are likely to increase in intensity, not least as EU countries seek to meet IPCC requirements and water framework directive targets.

A cap on fertilizer use is a fact of life for Danish farmers, however precision farming techniques provide them with the possibility to reduce applications without necessarily losing on yield and protein content.

SEGES sees these modern farming techniques as more likely to assist farmers than new fertilizer products (though nitrification inhibitors, and urea with urase inhibitors, are useful tools). Danish farmers are already well-educated in the use of satellite data (rather than tractor-borne tools), and state-of-the-art machinery.

The main challenge is to translate sensor input to valuable agronomic advice in the form of algorithms that ensure that fertilizer is applied in the optimum fashion, in the right dose as the particular soil and plant conditions in different fields require. Improved algorithms, for example to take account of variations in biomass, are necessary to do this effectively.

Farmers are unlikely to use more mineral fertilizer in the next years, though they will use it more efficiently. Significant growth in the organic sector (already accounting for 9% of farmland use) could reduce demand for mineral fertilizers. This would challenge the agricultural sector to manage combinations of mineral and organic fertilizer in an optimal fashion.

Danish farms are increasing in size. The average age of farmers is high. A core of highly professional farmers is likely to be the basis of farm production in future.

Combining farming, research and teaching

Peter Prankl, Austrian farmer

Peter Prankl farms part-time. He combines this with teaching at an agricultural college where he oversees field trials with a fertilizer company

Prankl's main teaching focus is on the use of electronics assessing soil quality and crop development.

He uses a mix of mineral and organic fertilizers on his farm.

Currently most Austrian farmers do not have the possibility to use satellite information, digital soil data, nitrogen sensors, etc.

Prankl uses digital information from satellites to take soil samples. He also uses satellite data for adapting nitrogen application, but he is a rarity in Austria. More research is needed for the practical use of the different digital data sources.

Most public/regulatory pressure on fertilizers has arisen due to poor explanations of the products to the public. Organic farming can cause as many environmental problems as non-organic, but the public does not perceive it this way. Farmers have to give plants what they need for efficient production.

In 2030 the fertilizer industry needs to be more involved with research institutes and with farmers. More knowledge about soil quality and the link to crop development is the main benefit the industry could bring – how to provide the necessary nutrients in the best, most accurate way. Few dramatic developments in fertilizer products themselves are expected.

Farming should move towards a future where fertilizers deliver more precise nutrition (applying more knowledge per hectare), but farmers need to see very clear results in their crops. This is not yet demonstrable. Farmers also need any new technical devices to be simple to use - they need to be easily transferable e.g. via an App (preferably via a mobile phone).

Prankl believes the Austrian Ministry of Agriculture will need to help improve this situation by setting up and financing projects to improve fertilizer use. In order to bring new techniques to farmers, both retailers and fertilizer companies need to be involved.

Horticulture leads the way

Jean Pierre van der Peijl, Dutch horticulture grower

Jean Pierre van der Peijl is a Dutch grower of around 200 varieties of outdoor nursery plants and shrubs. His plants are grown primarily in pots rather than in the ground

Van der Peijl uses a range of control release fertilizers (at a rate of 3.5kg/m^3) as a basic fertilizer to prepare the soil. In the growing period he takes soil samples and applies whatever additional fertilizer might be necessary, in a water solution. He usually does four such applications. This is all programmed into a computer based on analysis and his expertise. He receives excellent advice from his fertilizer supplier with whom he has a close relationship. Company advisers visit the farm each month.

All fertilizer supplies are purchased via a cooperative. Most of his fellow growers work this way.

The farm is completely automated. All fertilizers are applied via water – the fertilizers are dissolved in water. Computer programmes calculate what dose each plant requires. Fertilizer solution is applied via sprinklers.

Growers are concerned about public pressure for environmentallyfriendly practices. The Netherlands is a country that tries to lead others in terms of production and sustainability. Fertilizer use is under scrutiny because of concern about water quality. On Van de Peijl's farm all fertilizer is taken up by the plants and does not go into the environment. He runs a 100% closed system. He is involved in debates over fertilizer use. He believes fertilizers are very beneficial to his sector.

Van der Peijl believes that the pressure to use more organic fertilizers will increase. Organic fertilizers tend to be produced from composted materials, crop by-products and liquid sewage wastes.

Change happens continuously and growers are highly competitive. Van der Peijl does not foresee dramatic changes in techniques/machinery – the sector is already well-developed. There will probably be more combined fertilizer types in one product to reduce the need for several applications.

The main development is likely to be in better databases. There should also be better techniques for disease detection – some farmers are already using drones for this, with infra-red sensors. There will be better means of storing and using data and all available in better devices (i-Phones etc). Farmers receive training via membership of nursery groups. They have regular meetings to discuss new techniques and visit trade fairs to keep up-to-date.

Van der Peijl believes that the ornamentals sector is very dynamic and that it, rather than fertilizer companies, will lead developments.

The food industry has a say
Jan-Kees Vis, Unilever

Jan Kees Vis is the Director of Sustainable Sourcing at Unilever. Unilever supports nutritious, sustainably grown products and is committed to the sustainable sourcing of its key agricultural commodities.

Globally Unilever uses a high proportion of renewable materials. This will develop further. The company works closely with farmers and has established sustainable agriculture codes to guide them.

Unilever is interested in European agriculture and farming practices, including fertilizer use. Unilever wants there to be more research into sustainable planting. Unilever's 2010 Sustainability Plan aims to put sustainable living at the heart of business strategies. Unilever wants to encourage new products based on renewable and non-renewable materials and reduce the overall carbon footprint. One element of this is performance matrices, part of which would involve the nitrogen balance, but there are no established performance matrices yet. Fairly reliable methods of micro-nutrient analysis exist, but can these be matched with infrared sensors?

Unilever believes there is not enough understanding of soil health – the company includes in its codes the requirement for simple spade tests or analysis of soil organic matter. Soil depletion is a problem that is escaping attention. Unilever is also concerned about pollinators (insect decline leads to a smaller bird population). Unilever believes farming should be carbon-positive.

The company is frustrated that there is no good scientific data on the nitrogen balance.

The company operates under four main principles:
- Crop management of the right quality
- Minimum use of non-renewable inputs
- Minimum environmental impact and negative effects on biodiversity
- Support for rural livelihoods

Unilever does not distinguish between organic and mineral fertilizers. Vis does not believe the world can be fed if only organic fertilizers are used. Since the development of mineral fertilizers Unilever has focused on crops that respond to mineral fertilizer application because organic methods would not have the same yield effects (and 25% of land would have to lie fallow each year).

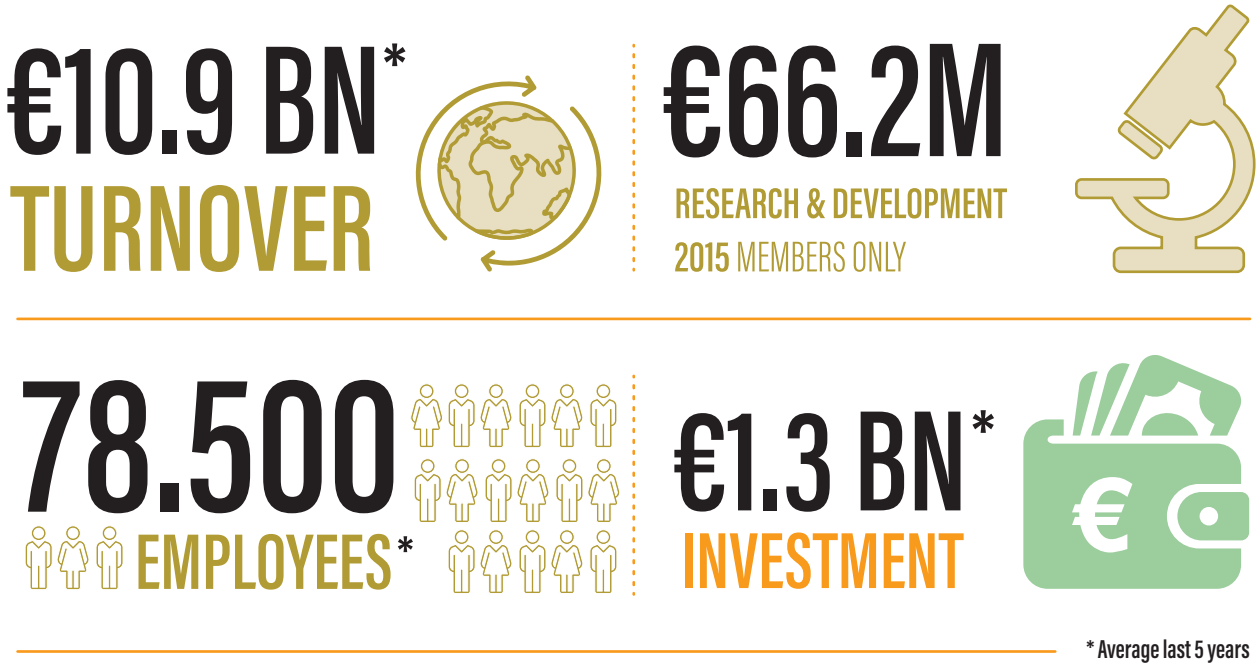
Unilever is a leading player in the Cool Farm Tool initiative because it promotes soil health. This health data should be matched in future by Nitrogen Use Efficiency data – this could produce a total farm tool with a matrix of carbon footprint and NUE data.

Vis believes that consumer habits are changing. 40% of all Dutch households, for example, now have regular meat-free days every week.

Annex 1

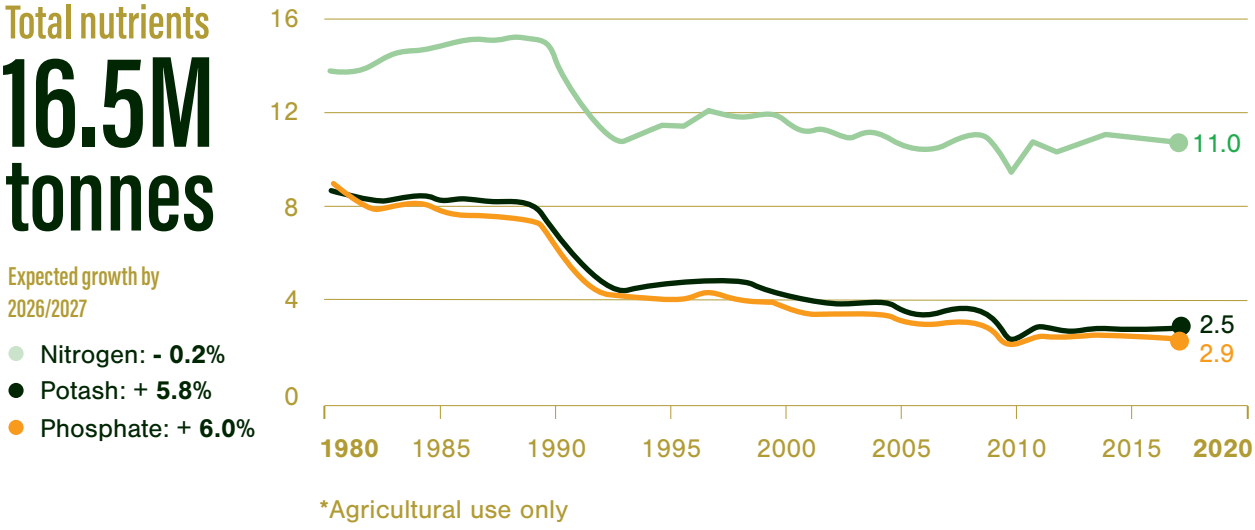
The European fertilizer industry at a glance

The European Fertilizer Industry



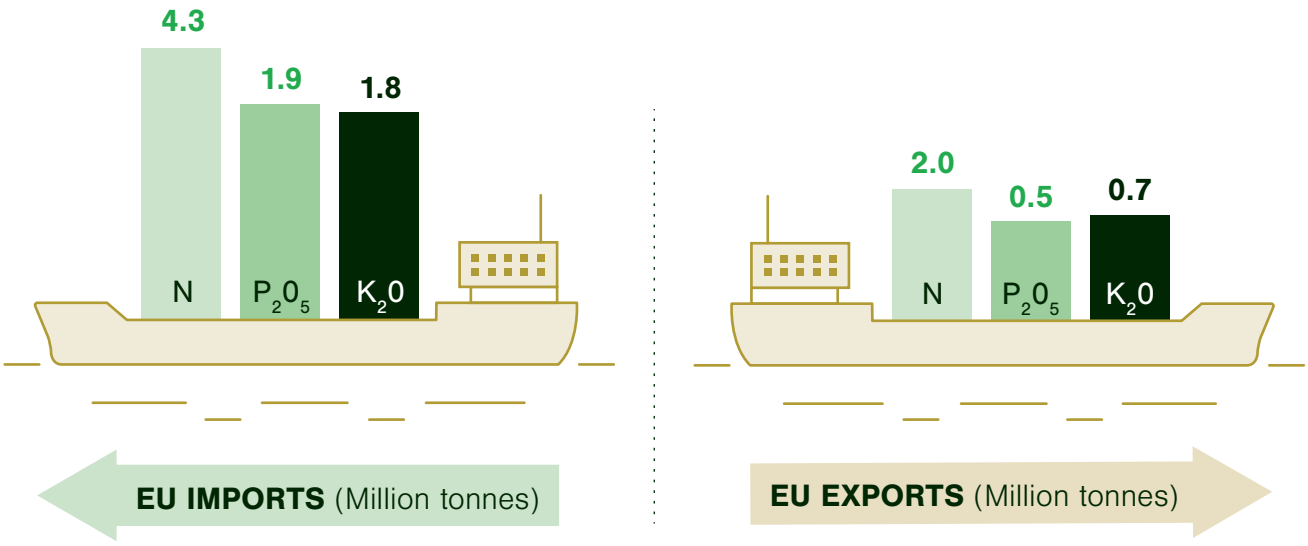
Source: Fertilizers Europe, 2018

Fertilizer consumption by nutrient



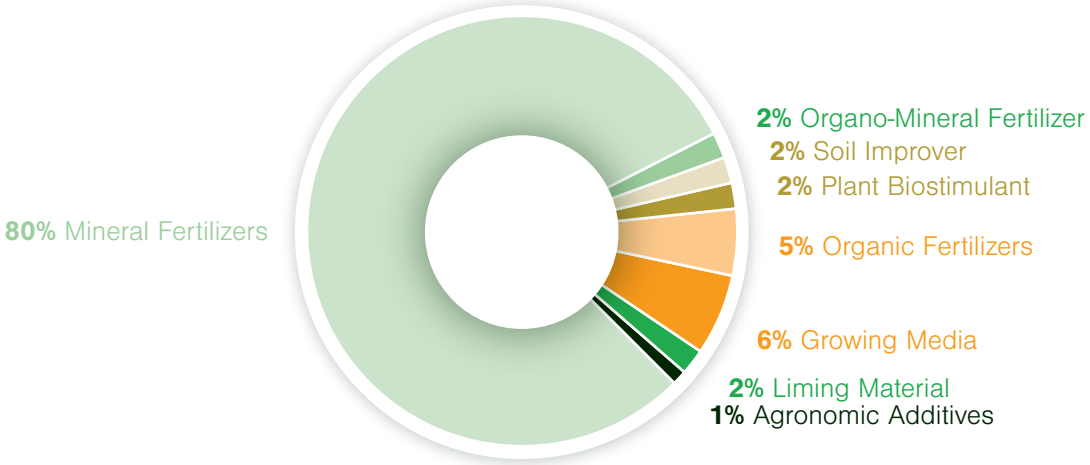
Source: Fertilizers Europe, 2017

Fertilizer imports and exports in the EU in 2017



Source: Fertilizers Europe /Eurostat, 2018

Market value of fertilizing products



Source: DG Enterprise, European Commission, 2012

Annex 2
Members of Fertilizers Europe

Fertilizers Europe represents the majority of fertilizer producers in Europe and is recognised as the dedicated industry source of information on mineral fertilizers. The Association communicates with a wide variety of insitutions, legislators, stakeholders and members of the public who seek information on fertilizer technology and topics related to today's agricultural, environmental and economic challenges.

Corporate

- AB Achema, Lithuania
- Grupa Azoty SA, Poland
- PFIC LTD, Greece
- Anwil SA, Poland
- OCI Nitrogen BV, The Netherlands
- NKF s.a., Greece
- Borealis AG, Austria
- Petrokemija Plc, Croatia
- Eurochem Antwerpen BV, Belgium
- ICL Fertilizers Europe BV, The Netherlands
- Azomures SA, Romania
- Yara International ASA, Norway
- Lovochemie as, Czech Republic
- Nitrogénmüvek Zrt, Hungary
- CF Industries, United Kingdom
- BASF AG / Fertilizer BU Europe, Germany
- Fertiberia SA, Spain & Portugal

National Associations

AIC Agricultural Industries Confederation

ANFFE Asociación Nacional de Fabricantes de Fertilizantes

ASSOFERTILIZZANTI Associazione Nazionale Fertilizzanti

BELFERTIL Belgian Mineral Fertilizer Association

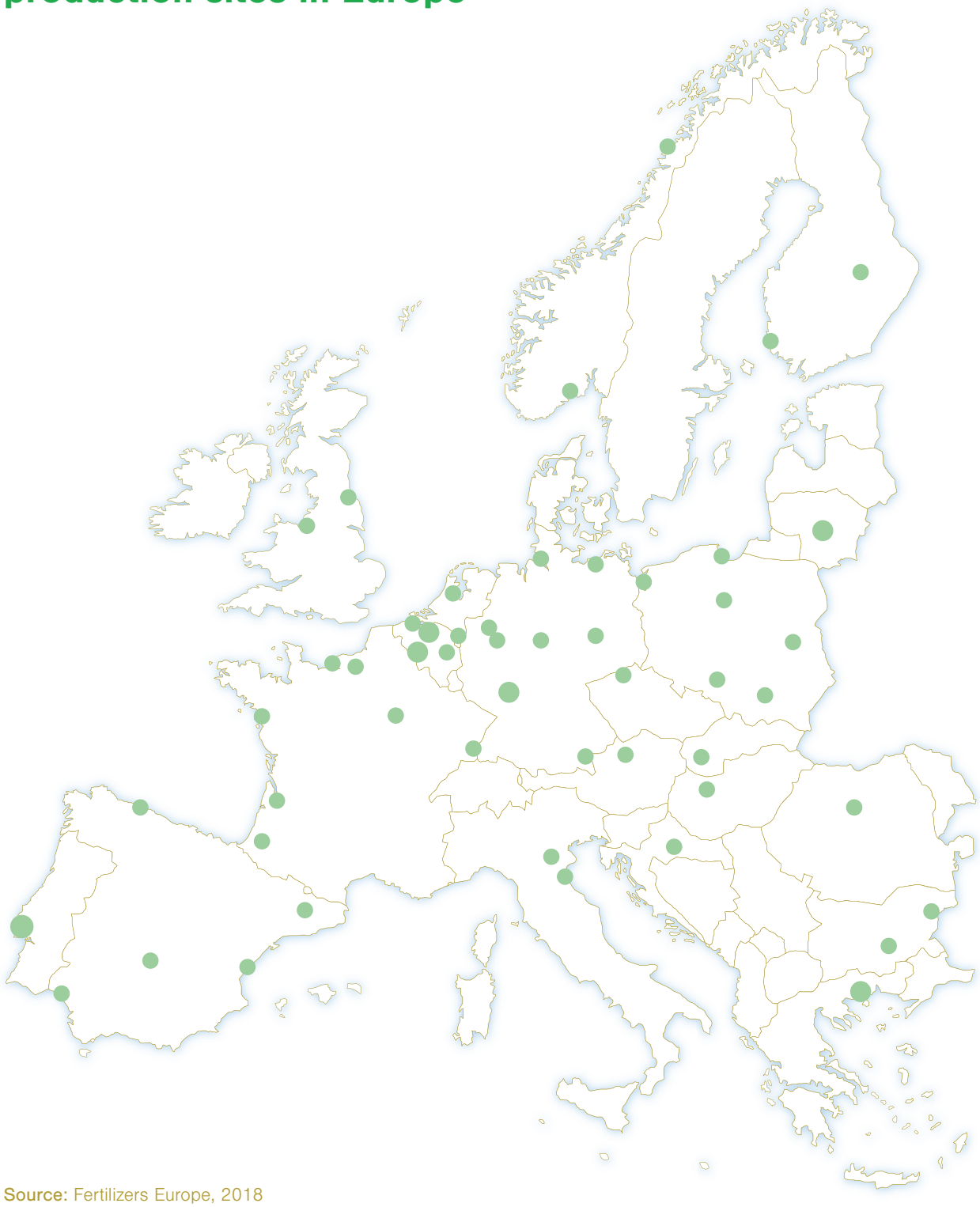
IVA Industrieverband Agrar e.V.

Meststoffen NEDERLAND Fertilizers Netherlands

PIPC Polish Chamber of the Chemical Industry

UNIFA Union des Industries de la Fertilisation

Annex 3
Major fertilizer production sites in Europe



Source: Fertilizers Europe, 2018

Annex 4

In-depth interviews and online survey

During 2018 Fertilizers Europe undertook two consultation exercises with stakeholders: a series of interviews with a cross-section of stakeholders about the future of fertilizers in Europe; and, an online survey in which participants answered over 60 questions related to the production and use of fertilizers.

Fertilizers Europe would like to thank everyone who participated for their valuable input!

A) Interviews

Interviews were conducted with a variety of stakeholders, over the February to September 2018 period. The largest group was farmers and growers; others included an environmental NGO, an agricultural machinery manufacturer, a technology provider to the fertilizer industry, a provider of farm advice, academics/researchers and a food industry representative. All interviewees had a perspective that went beyond their own business or responsibility.

Iris Bouwers Vice President of CEJA (European young farmers organisation)
Dr. Achim Dobermann Director and Chief Executive, Rothamsted Research in the UK
Prof. Janusz Igras (Gen. Director) New Chemical Syntheses Institute (INS) in Poland
& **Dr. Krzysztof Borowik** (Dep. Manager)
Andrea Kohl Programme Director, WWF European Policy Office (Brussels)
Valentin Marginean Farmer from Romania
Svend Erik Nielsen Senior Proposal Manager, Haldor Topsoe in Denmark
Prof. Oene Oenema Professor in Nutrient Management and Soil Fertility,
Wageningen University in the Netherlands
Prof. Peter Pickel Manager External Relations, John Deere in Germany
Kristoffer Piil (Senior Specialist) SEGES (Independent farm advisory service) in Denmark
& **Leif Knudsen** (Agronomist)
Peter Prankl Farmer and agricultural college teacher from Austria
Jean Pierre van der Peijl General Manager, Van der Peijl Tuinplanten in the Netherlands
Jan Kees Vis Director of Sustainable Sourcing, Unilever in the Netherlands

B) Results of Fertilizers Europe online survey

Fertilizers Europe conducted an online survey in the January to March 2018 period aimed at establishing the views of a wide cross-section of stakeholders on the future of the EU fertilizer industry. Fertilizers Europe members also participated. In total 135 responses were received, two thirds coming from within the fertilizer sector and one third from other stakeholders.

The survey asked the respondents to point to likely changes in society, farming and fertilizer production and also determine how important these changes would be for the fertilizer sector.

There were no big differences of views between responses inside and outside the fertilizer sector.

Main conclusions of the online survey

- The survey showed a clear likelihood of future public emphasis on producing food sustainably and on demand for labelling and certification. This development was also deemed to be important for the fertilizer sector.

- Public concerns over air quality and water quality are most likely to be the coming issues, and both are very important for the sector. Soil quality did not score so highly. Development of best practises for fertilizer use was deemed to be very important for the fertilizer industry, even if the public concern is lower.

- In terms of environmental regulation, it was clear that increased regulation of farming, especially when it comes to use of fertilizer plans and the mitigation of climate change effects, is very likely. This was also deemed to be the most important question for the fertilizer sector.

- The use of IT on farms and of precision agriculture were very likely developments – a view shared by nearly all respondents. In terms of importance, most respondents highlighted the need for more effective techniques for applying fertilizers.

- Most respondents also deemed further consolidation of the fertilizer industry likely, but in terms of importance for the sector respondents prioritised developing advice on plant nutrition and putting more emphasis on quality than price.

- The survey showed a very low likelihood of a radical breakthrough in fertilizer production technology, but at the same time an expectation of increased requirements to use waste raw materials. Of highest importance to the sector were supply issues, such as access to natural gas at competitive prices.

- In terms of the economic environment many respondents pointed to concerns for a level-playing field and the fertilizer industry's competitiveness in the future, and so corrective actions such as anti-dumping were deemed important for the sector.

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