NITROGEN: IN ALL FAIRNESS

KVAB Thinkers Programme – 2024

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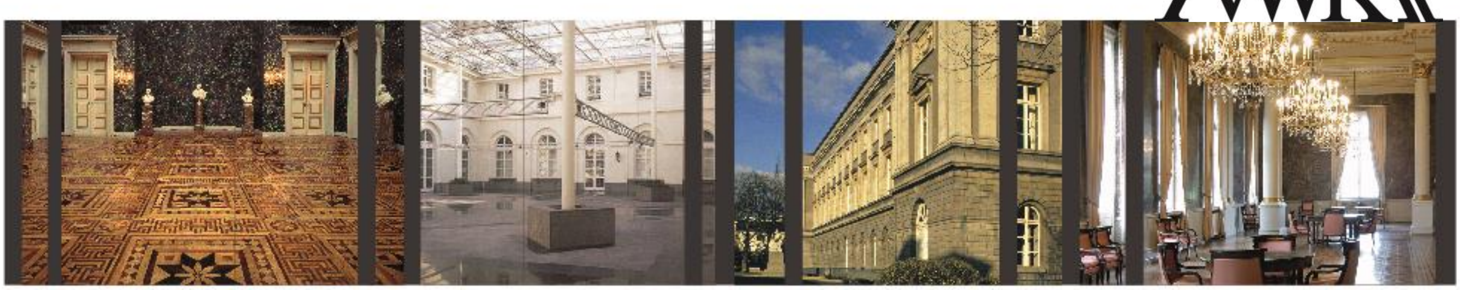

REDUCING NITROGEN DEPOSITION IN FLANDERS

Final report Thinkers' programme 'Nitrogen: in all fairness'

Royal Flemish Academy of Belgium for Science and the Arts (KVAB)
Class of Technical Sciences (KTW)

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1. Preamble thinkers' programme on nitrogen

The Royal Flemish Academy of Belgium for Science and the Arts (KVAB), Class of Technical Sciences (KTW) organized a Thinkers' Program in 2023-2024. Two international experts ("the thinkers") were appointed: Ana Soares, Professor of Biotechnology Engineering at Cranfield University, UK and Thomas Christensen, Professor of Environmental Engineering at the Technical University of Denmark. The coordinators of this thinkers' cycle were Willy Verstraete (UGent), Erik Smolders (KU Leuven) and Siegfried Vlaeminck (UAntwerpen). The steering committee further consisted of KVAB members Patrick Maselis, Paul De Bruycker, Egbert Lox and Kris Verheyen, and the entire process was facilitated from within the KVAB by Inez Dua and Filip Staes.

This text is based on an extensive set of fact-finding interviews and discussions between the thinkers and key knowledge parties and stakeholders (Department of Environment, ILVO, VITO, INBO, VLM, Essenscia, Boerenbond, BFA, Intendant Nitrogen Problems, the Brouns Cabinet, the Demir Cabinet, WeComV, Vlakwa, the PAS expert panel, supplemented by academic experts from Wageningen University & Research, UGent, VUB and UAntwerpen), supplemented by consensus insights from the scientific literature and expert knowledge.

On March 5, 2024, a symposium was organized in which stakeholders and experts presented all aspects of this complex challenge, discussions were held, and the thinkers presented their conclusions. In the afternoon, the attendees joined four break-out sessions in which debates were held and votes were taken around key statements. The gathered input and feedback from these workshops are also summarized in this document.

2. International expert thoughts on the N deposition issues in Flanders

Thomas H Christensen (Technical University of Denmark) and Ana Soares (Cranfield University, UK)

Introduction

The regulation of N deposition in Flanders is high on the political agenda and a topic often discussed among scientists and in the media. No easy solution to the issue is at hand; it seems like a Gordian knot where industry, agriculture and protection of natural habitats are strongly entangled. However, this knot cannot be untied by the cut of a sharp sword, because industry, agriculture and nature all have to function and thrive in the future. A balanced and fair solution must be found.

N emissions and deposition

In this section, N emission and deposition data are summarized and interpreted, sourced from the Flanders Environment Agency (VMM; https://www.vmm.be/lucht/stikstof). Emissions of the gaseous eutrophying and acidifying nitrogen compounds ammonia (NH_3) and nitrogen oxides (NO_x) have been very high for decades in Flanders. The top three emitting sectors for these nitrogen species are agriculture (53%), transport (30%) and industry (9%). Ammonia emissions are nearly exclusively (96%) from agriculture, while transport emits most (56%) nitrogen oxides, followed by industry (16%). Emissions have been decreasing over the past 15 years (2008-2022), particularly NO_x emissions from transportation (-58%) and industry (-36%). The emissions from agriculture, however, have been relatively stable, with a minor decrease of 11% only (Figure 1).

N deposition in Flanders is high but only partly linked to local emissions since most of the emissions from Flanders (78%) are exported. Imports are also significant and contribute to almost half (47%) of the deposition in Flanders. Looking at the balance (Figure 2), Flanders is a net exporter of emissions, exporting around four times more than is imported. This implies that the deposition in Flanders depends on how neighbouring countries reduce their N emissions and that the policy in Flanders impacts deposition outside of Flanders.

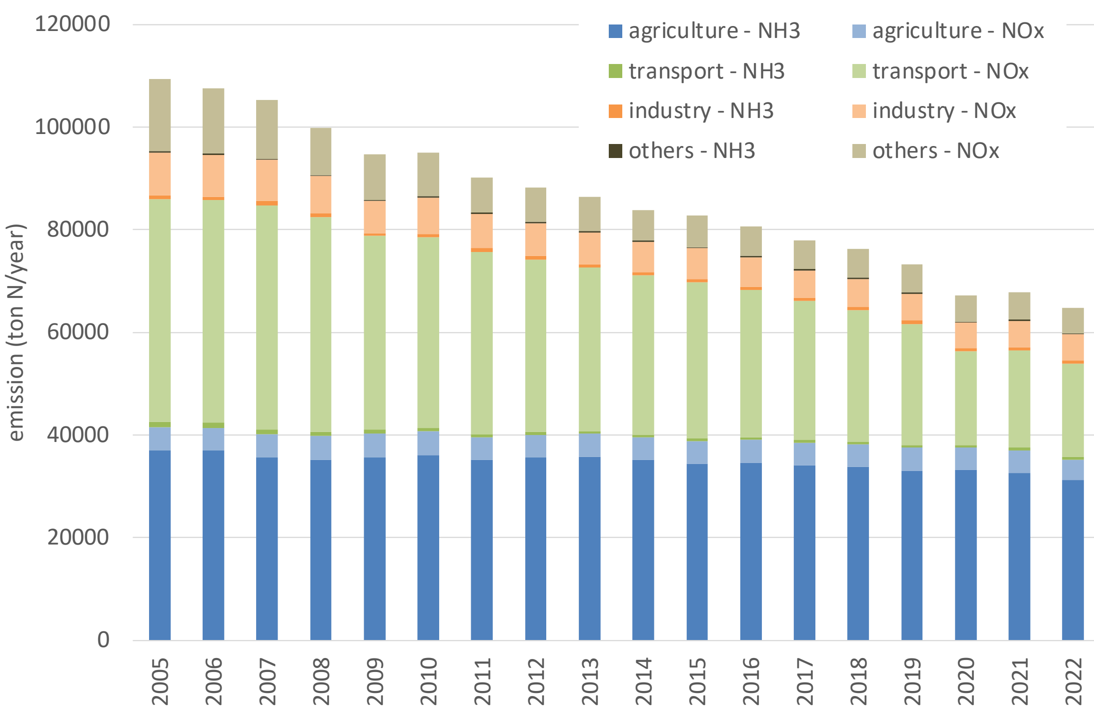

Figure 1. Evolution of the NH_3-N and NO_x-N emissions (ton N/year) by the different sectors in Flanders (2005-2022), based on the data from the Flanders Environment Agency (VMM; https://www.vmm.be/lucht/stikstof)

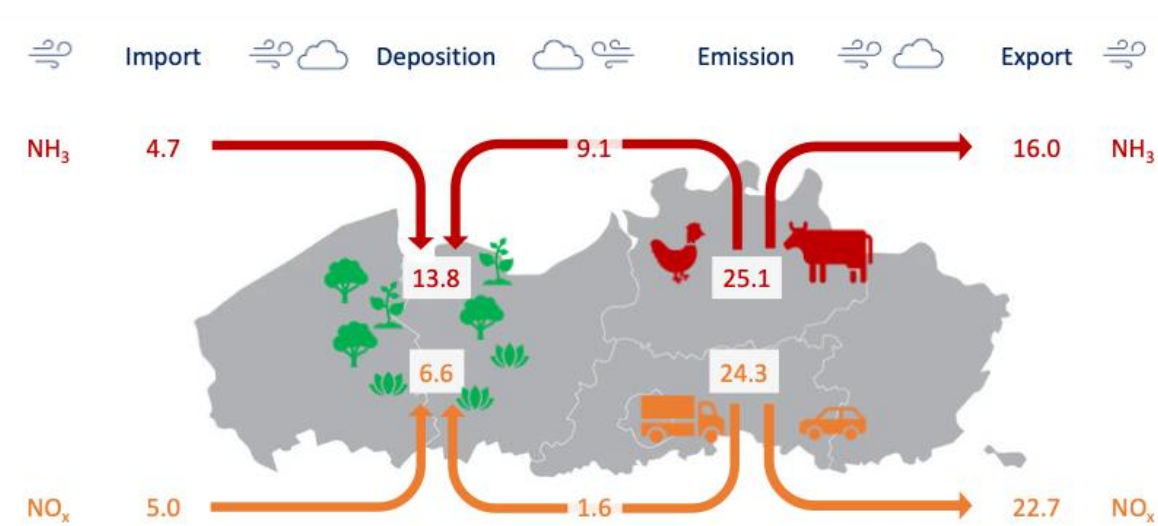

Figure 2. The nitrogen balance for NH_3 and NO_x in Flanders (kg N/ha/year), based on the 2021 emission and deposition data from the Flanders Environment Agency (VMM; https://www.vmm.be/lucht/stikstof), with recalculated emission figures per hectare based on a total surface of 1 362 600 ha.

The link between emission and deposition is different for NH_3 and NO_x. NO_x tends to travel further than NH_3, partly because some NO_x is released at high altitudes and partly because of differences in their atmospheric chemistry. Consequently, the majority (63%) of the emitted NH_3 deposits in Flanders, while this is a minority (24%) for NO_x. Agriculture (63%) and import (34%) are the key contributors to NH_3

deposition, with minor contributions from transport (0.9%) and industry (0.7%). For NO_x deposition, import (76%) and transport (12%) play major roles, and smaller contributions come from agriculture (3.8%) and industry (3.6%) (Figure 3).

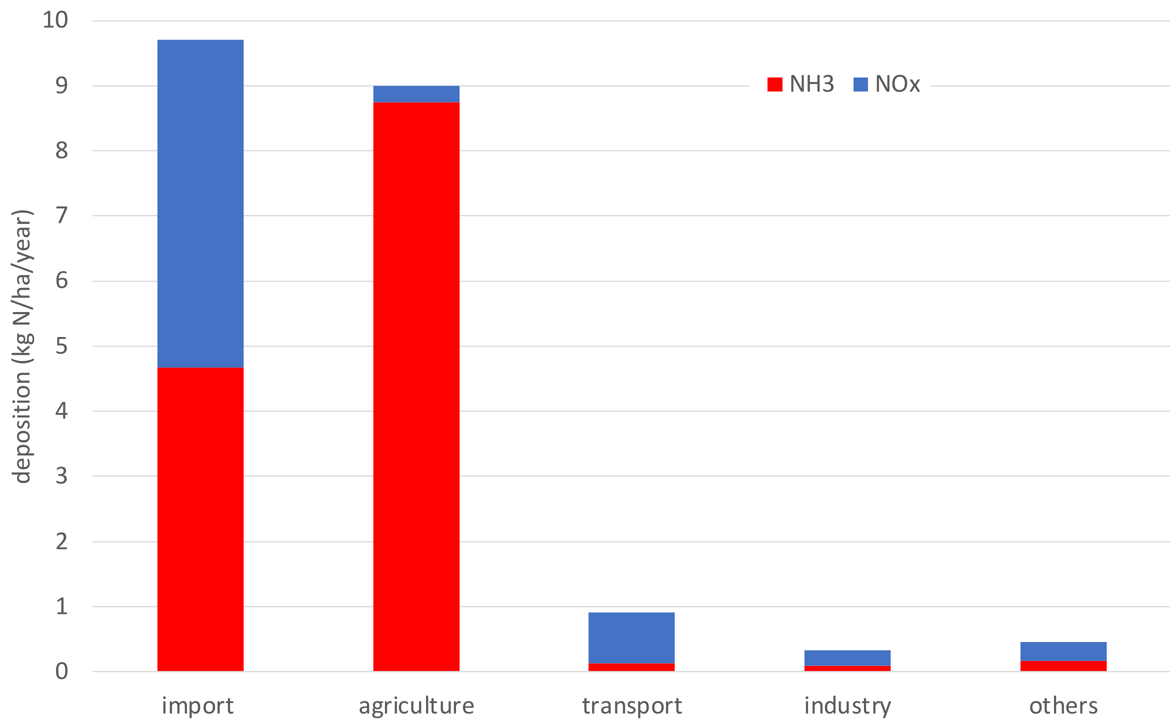

Figure 3. Contributions to the deposition of NH_3-N and NO_x-N (kg N/ha/year) by import and the different sectors in Flanders (2021), based on the data from the Flanders Environment Agency (VMM; https://www.vmm.be/lucht/stikstof)

The above facts indicate that the main challenge is to reduce ammonia emissions from agriculture. Indeed, agriculture causes 44% of the deposition linked to their share of about half (53%) of the total N emissions. In contrast to most other sources, a significantly decreasing emission trend has not been observed in the past 15 years. Note that the latest data available are from 2022.

The agricultural challenges

While agriculture for decades has played a major role in Western economies, its contribution to the economy is less profound today in terms of GDP and in terms of number of people employed. However, it is fundamental for a country to have agricultural production from the point of view of a secure and local food supply.

However, modern agriculture – and, in particular, animal husbandry – faces major challenges in the years to come. These challenges are linked to the fact that animal husbandry has developed away from its natural connection to the land. This has led to high densities of animals, import of feed, export of manure and high environmental emissions. The natural link between land and the number of animals no longer exists. This is the fundamental reason for many of the problems that agriculture faces. Agriculture is not only facing an NH_3 emission problem, but also its contributions to climate change, surface and groundwater pollution, pesticide residues, animal welfare, and loss of biodiversity are subject to strong criticism and calls for regulation beyond what has been achieved so far. Agriculture has been met with many regulations during the last decades, but in general, they have not been enough to match the development in agricultural practice and have not led to major environmental improvements. Thus, in addition to the NH_3 emissions problem, animal husbandry is expected, in the years to come, to be met with substantial demands for more sustainable ways of operation.

Agriculture is also facing a social challenge. Many older farmers do not expect to find successors to take over their farms. This is likely to lead to takeovers by agricultural corporations or companies, which in the long run will lead to fewer but bigger and more industrialized farms. This may not necessarily be a negative development because it could lead to more investment in facilities and equipment, better working conditions and a better work-life balance for the people employed. However, it may also lead to the opposite, where the economic focus overrules all other issues. In addition, it will remove the historical link between the farmer owning and managing the land with a view to both yearly outcomes and long-term quality aspects. The narrative of the farmer being the steward of the land and the provider of our food is challenged and maybe dying as fewer people today have family links to the farming community.

These many challenges that agriculture faces, must be kept in mind as we discuss the regulation of NH_3 emissions since any measure introduced must work within the changing framework conditions. In addition, it should be carefully evaluated how measures to reduce N deposition are affecting the framework conditions and the possibilities, by other initiatives, of addressing the other challenges. The goals for agriculture, being environmental or social, are, of course, to be set politically.

In addition, there is a risk that regulating N emissions from animal husbandry will become the battleground for other environmental and social challenges related to this type of activity. This could effectively inhibit the introduction of suitable regulation for managing N emissions.

The PAS report and N regulation

The scientific and administrative approach to regulating N deposition is described in the PAS report (VR2023 1503 MED0103/2). The quintessence of the approach is the linking of N emissions from specific sources to N deposition on specific areas, in this case, SBZ-H areas, using air quality models. SBZ-H areas are special protection zones identified to implement the EU Habitat Directive (92/43/EEG). There are 38 SBZ-H areas in Flanders with a total surface area of N-sensitive habitats of 73 569 ha (varying between 248 ha and 6657 ha per SBZ-H). The Flemish government agreed that limiting the N deposition on the SBZ-H areas is a prerequisite for bringing habitats and species to a favourable state of conservation. According to the EU, a favourable state of conservation of all habitats and species must be achieved by 2050, but Flanders also set criteria for progress by 2030.

Each habitat type has been assigned a Critical Deposition Value (CDV), representing deposition of N in kg per ha per year (kg N/ha/year), which is the maximum permissible deposition that a particular habitat type can tolerate without being affected - according to current knowledge. It is acknowledged that reducing N deposition in itself, may not be enough to restore the habitat. The CDV values are scientifically defined.

For 65% of the nitrogen-sensitive habitats that are already present in the SBZ-H areas (i.e. 22 162 ha out of 34 328 ha), in particular the oligotrophic and semi-oligotrophic areas, the N deposition exceeds the CDV (and has been doing so as long as monitoring has been in place). This has demanded that an acceptable annual N deposition be defined in order still to allow some, but regulated activity in the vicinity of the SBZ H-areas. To assess the impact of each source, as it is currently or as it would be according to planned changes in the operation, it has been necessary to distribute the acceptable annual deposition among the sources.

The PAS report describes this in detail and suggests values to be used in the calculations. From a scientific and regulatory point of view, this approach is defendable and sound, as long as the data and models used are sound. The principles are stringent and logical.

Regarding the scientifically based assumptions and data, we have the following comments:

- The source term based on an emission factor per animal, specified for the type of animal, the operational mode and the presence of emissions controls, is considered acceptable although we were informed that more and newer data would be recommendable.
- The air quality models used to link emissions to deposition are considered sound, although we have little information about the accuracy of the local model component (at less than 500 m scale). We suggest that this be further assessed and, if needed, also improved.
- The CDVs are based on ecological principles, and we have no reason to doubt their basis, but we find that they should be used as target values and not as absolute values that need to be met immediately.

The controversy of the conclusions of the PAS report is not due to the scientific principles used in the report but the fact that the approach taken and the "soft" data used to define acceptable depositions (5% of CDV, the proxy for non-significant impact) and to distribute these among sources, leading to a maximum contribution per agricultural NH_3 source of 0.025% of the CDV. This results in very restrictive results that are hard to accept from a practical point of view. Addressing an SBZ-H area with a CDV of 10 kg N/ha/year, the max deposition from a single source thus is 2.5 g N/ha/year, which is an extremely low value with very dramatic consequences at the sources that potentially cannot be dealt with. This again stops development and investments that could reduce N emissions and N deposition.

The values chosen to reach the 0.025% impact score represent a unique situation (PAS report VR2023 1503 MED0103/2, page 75). All current installations below that limit yield a cumulative impact score of, on average, only 0.32% of the CDV. This is far from the 5% target. However, in one case (the worst case with data from 2015), the added value is 4.9% (PAS report, page 75). However, one single case should not be the basis for deriving limits applied to 36 N-sensitive SBZ-H areas. Incremental sets of data should be developed. Risk assessments should avoid the multiplication of safety factors, which clearly happened here (i.e. the worst case with data from 2015).

Proposed adjustments and further considerations regarding N regulation in Flanders

We fully understand that further regulation of N-emission and N deposition is needed in Flanders to meet EU requirements regarding SBZ-H areas. We also fully accept that SBZ-H restoration must be complete by 2050, and N deposition, therefore, must be fully controlled by 2045, as suggested by the PAS report. However, we suggest that the Flemish government consider some changes and modifications, using the same scientific principles and keeping the same goal, but implementing regulation slowly and with less bureaucracy focusing on the significant aspects and allowing for a durable development of the involved sectors.

Things to consider are:

1. Industries should not be regulated by the PAS principles. Industry emits very little NH_3 but contributes significantly to NO_x. NO_x emissions from industry have been declining over time, and this trend should be continued. Industrial emissions are primarily through pipes and stacks and can be regulated by abatement technology. Demand that best-available technologies be implemented everywhere no later than 2028. Permits are renewed regularly and can be reviewed at any time where needed. It may be

useful to define a lower discharge value per industry to demand the best available technology for NO_x reduction so insignificant small sources are unaffected.

2. Traffic and associated facilities should not be regulated by the PAS principles. Exhaust emission limits should be strict on all traffic vehicles, which would also benefit urban air quality. Vehicle electrification is believed to be taking place rapidly due to climate change initiatives and will, in itself, reduce NO_x emissions from traffic.
3. Agriculture should be regulated by the PAS principles but with some modifications:
    a. The acceptable deposition on SBZ-H areas already exposed beyond the CDV should be changed from 0.025% to 0.1 % of CDV. This will decrease the number of sources exceeding the value by 70% but still address about 60% of the problem (rough estimate based on Table 4.6 in PAS-report, page 75). If the CDV is 20 kg N/ha/year, this is equivalent to 20 g N/ha/year from each source. This runs until 2035, when the overall progress is assessed, and further initiatives must then be considered if sufficient progress has not been made.
    b. A lower limit in terms of type and number of animals should be specified below which no regulation is enforced.
    c. It should be allowed to prove your case with your own data if one believes in doing better than standard data (maybe due to different fodder types, different animal species, different emission controls).
    d. Methods for reliable integrated monitoring of stables should be developed and standardized.
    e. Exempting elderly farmers who own their own farm and who agree on retiring before 2030 (maybe already in PAS).
    f. Abatement technologies must be approved for installation, and contractual specifications of operation must be introduced. A monitoring control program must be established to check the efficiency. For new abatement technologies, selected farms could be defined as test facilities, where the operation is followed, for example, for 3 years, and results are made public. The installation and operational costs could be split between the public, the farmers' association, and the farmer. A properly funded and fully independent committee must have the power to bring the abatement technologies forward in a well-organized transparent way by regularly assessing the performance of existing technologies at the one hand and by introducing and implementing improved or new technologies.
    g. The PAS model database should be continuously updated; in particular, the source term data should be revised and supplemented.
    h. The small-scale modelling, i.e. within 500 m from the emission source, used in the PAS approach should be revisited and assessed in terms of accuracy.
    i. Monitoring of actual N deposition on a range of selected critical Natura 2000 areas should be made regularly to assess the progress of the initiatives.

Concluding remarks

The suggested modifications, which we hope will be considered by the Flemish government, will lower the emissions and deposition of N in Flanders, but slightly slower than what the current PAS approach would do. Remember that the deposition on the critical SBZ-H areas has been exceeded for several decades and a sudden and complete revolting of this situation makes little sense and must be balanced against the consequences of this for other activities crucial in the Flemish society. The proposed modifications offer many improvements in terms of:

- Reduce the number of units needing to undergo the PAS procedure while still focusing on the main part of the problem.
- Avoid inhibiting initiatives in industry and in the traffic area where new technologies already have lowered the emission substantially.
- Support the development of better data and models.
- Support the establishment of test beds to verify the efficacy of existing and new abatement technologies independently, and disseminate results openly.
- Provide administrative experiences that can lead to adjustment of approaches.
- Avoid pushing for social development in agriculture; take the ageing population of farmers into account.

3. Insights break-out sessions symposium

On March 5, 2024, a conference was organized in which the thinkers presented their conclusions, and scientists and stakeholders made presentations. In the afternoon, all attendants, about 140, joined break-out sessions in which the following themes were dealt with and where the following questions were presented, and attendants could discuss and vote. The summary is described below

Nature preservation

Statement 1

> ***“A nitrogen policy that focuses only on emission reductions and not on depositions to return European habitats to good conservation status is sufficient.”***
>
> ***Result:*** *Equal number of persons agree and disagree with this statement.*
>
> Summary: in practice a policy based on a combination of emission reduction and deposition is probably the best option, giving more legal certainty to emitters, while keeping track of the effectiveness of the applied measure to achieve a good state of conservation of the special protection zones under the Habitats Directive.
>
> A policy focused on deposition and exceedance of Critical Deposition Levels has the advantage of being more legally grounded through the state of conservation in the Habitats Directive, although models to determine deposition involve high uncertainty. A policy-oriented towards emission reduction has the advantage of applying the equity principle: every emitter (regardless of industry or agriculture) must comply with the same policy, regardless of its location relative to special protection areas. Moreover, an emissions policy would build in more legal certainty for the emitting company ('You can try so hard to reduce emissions, you don't know where the nitrogen you emitted will fall down: if I undertake something, is that enough?'). An intermediate path of integrated policies was suggested, where steering is done through emissions, but evaluation of policies is done through deposition and state of conservation.
>
> Tools should also be developed that allow N in depositions to be allocated to sources and link changes in N deposition to emission reductions, although this is recognised as difficult.
>
> Finally, it was also pointed out that other factors besides N deposition also contribute to the failure to achieve a favourable state of conservation, so a policy focus on nitrogen alone is not enough to achieve a good state of conservation.

Statement 2

> ***“Achieving a good conservation status of habitats within Habitats Directive areas is the indicator of a broad-based, effective nitrogen policy in Flanders.”***
>
> ***Result:*** *Participants did not agree with this statement.*
>
> Summary: besides nitrogen, many other factors impact the conservation status of habitats, hence the disagreement with this statement. However, the participants gave full support for a rephrased statement with ‘the indicator’ replaced by ‘an indicator’. Support is given because the statement

then reflects a broader perspective on the importance of a good environmental quality for people and nature.

As mentioned in the discussion on statement 1, the state of conservation is not only affected by nitrogen policy, but also by water and climate policy, among others. The difference with other policies could lie in the heavy interference of nitrogen with permits. As a solution, it was suggested to separate permits from nature policy and provide other frameworks than nature policy such as the Flemish Air Policy Plan. If drawn more broadly than nature policy, a more holistic approach could be more helpful.

The statement can also be interpreted differently: we should not be blinded by those small patches of habitat within special protection areas. If 'the indicator' was replaced by 'an indicator', there would have been a resounding 'yes' vote on this statement. The discussion showed that the broader picture should be seen: a good nitrogen policy should also ensure that the quality of our environment in general improves and that we create a resilient habitat. A more robust nature, a more integrated vision of policy and attention to the obvious links with human health were put forward as important steps in the process.

Statement 3

"A good conservation status of European habitats can also be achieved through broader adapted nature management that mitigates the effects of nitrogen deposition and addresses other nature-threatening factors (e.g. desiccation)."

Result: *Participants had a divided opinion on this statement.*

Summary: critical questions were raised about the way how to define a good conservation status, certainly in an era where many other environmental drivers – like climate – are changing as well. There is a need for a holistic framework that allows to understand the relative importance and trade-offs of the different drivers.

During the discussion, the uncertainty of how important those other threatening factors are was pointed out, and knowledge about them is necessary to estimate whether we would succeed in reducing the effects of all those nature-threatening factors with nature management. Moreover, not all nature is engineerable and it is not feasible to reduce all pressures with nature management: there are limits to the possibilities of nature management.

Critical questions were raised about how the status of conservation is determined: how is it done, is it reliable, who sets the rules, are the references not outdated, what kind of nature do we want in a changing world (with climate change and exotics), what makes the loss of four species when 1,000 remain, do we want the nature of two centuries ago or 'modern' nature? The discussion showed that there are a lot of ambiguities about how the status of conservation of a special protection area is determined, how criteria are established and updated, why a favourable status of conservation is targeted and tout court why biodiversity is important.

The need for a trade-off framework was raised to integrate and weigh up the impact of a development, investment or business in different areas. For example, an adjustment in policy or a development may reduce nitrogen pressure but at the same time cause a negative impact on the climate through increased CO_2 emissions. Or vice versa, a desirable climate-related development can now be prevented because of a limited (temporary or otherwise) increase in nitrogen emissions. The strict legal approach to each environmental issue separately currently prevents a high-level consideration of those costs and benefits.

Statement 4

"Monitoring dry and wet nitrogen deposition in nature reserves is crucial to better understand what type of nitrogen policy is needed in the long term."

Result: *A clear majority of participants agreed with this statement.*

Summary: measurements are considered useful and important, but the feasibility of large monitoring networks is questioned.

Measurement is always necessary: determining actual nitrogen depositions is necessary, be it for a site-specific statement, be it for the validation of deposition models. However, the feasibility of deposition measurements (large investment in time and funding) was questioned, as was the representativeness of a limited number of measurements because of the high temporal and spatial variability of nitrogen deposition, due to variation in meteorology, landscape structure, etc.

Technological emission reduction

Statement 1

"Current financial incentives from the government to research institutions and technology providers for the development of innovative technologies are insufficient."

Result: *Major agreement that the R&D for innovative technologies needs to be better organized.*

No data are available about specific government support for R&D in agriculture regarding N-emission reduction technologies. There is no transparency on this. Of course, the more general channels for research support can be used.

Particularly missing are long term experimental set-ups in which different stakeholders (farmers, technology providers, environmental inspectors) participate, i.e. so-called " test beds". In Flanders, there is no test bed scheme. Moreover, in Flanders, one cannot build a stable to test a particular technology. Some technologies are in the pipeline, but quite a few projects are submitted to the committee responsible for providing the permit, i.e. the WeComV. The financial complications for the farmer are judged to be much too large. A timeline of 5 years (build, test etc) is a race against time and hence not attractive for technology providers; at least a period of 10 years should be provided. There is also great uncertainty about what will happen to PAS after 2030, which makes investment difficult now. This causes players to leave the agricultural sector.

Statement 2

"When developing cost-effective abatement technologies, the main focus should be on the combination of improved barn structures and air purification systems."

Result: *There is major agreement that not only technical factors are important, but also prevention, for instance, by means of feed adjustment and proper manure management.*

While the focus is correctly on air treatment, attendees feel the preventive steps are also important. Quite "cost-effective" measures, such as optimal management of the feed composition and management of the manure, have been studied and deserve to be implemented first and foremost. Yet these are not sufficient to meet the high reduction targets. So air purification systems are necessary to meet them. Unfortunately, there is no concrete insight into the cost-effectiveness of different approaches. It would be good to have some kind of simplified catalogue. Or some kind of benchmark parameter: EUR total cost/kg ammonia-N emissions avoided.

It is also of critical importance that not part but the whole of the measures taken to decrease emissions are fully documented. Scrubbing the off-gases to produce ammonium salts, which then have to find application in agriculture, might sound fine, but the overall reality of the further use of these salts has to be clearly established, and all costs involved need to be documented. Indeed, the value chain of a ‘recovery’ product is rarely as positive as depicted and should be judged on the basis of a realistic Life Cycle Analysis (LCA).

Statement 3

“The procedures to include new methods in the PAS list through VLM and WeComV are complicated and expensive. This makes it difficult for technology providers to introduce new solutions. This approach should be reviewed.”

Result: *The opinions on the procedures currently applicable are diverse. There is a need to clarify the actual status of how WeComV will proceed in its recent setting.*

The WeComV has been re-started about 1 year ago. It should be given sufficient time to come to terms with the complex tasks and time frames it faces. The committee should be adequately staffed, and all measures should be taken to allow it to operate with all freedom and in full transparency. It is strongly suggested that the committee exchanges information with the various similar centres and institutions in the neighbouring countries. It is of paramount importance that the committee should have at its deposition a roadmap of the legal aspects applicable in Flanders, which is sound and doable for all stakeholders.

Statement 4

“WeComV is so important that it should have more capacity/availability so that a smooth flow from demand to advice is generally possible.”

Result: *The majority of the participants fully favour a strong and effective WeComV.*

It was recently decided to expand the capacity of WecomV: 3 additional scientific experts (5+3=8 total) + 1.5 additional person administrative support (1.5+1.5=3 total). It is emphasized that the members of the WeComV should have a spectrum of experiences and should deal with science and not with policy aspects.

Measuring, modelling & implementation

Statement 1

"Measurement: Measuring nitrogen deposition in the order of magnitude kg N/hectare/year for land areas between 248 and 6657 hectares needs a sampling methodology worked out in detail and validated on the basis of higher statistics. This is so far insufficiently scientifically based in the procedures applied in Flanders."

Result: *The participants are bewildered by the complex issues involved in nitrogen in the environment. The overall comments point to the need for better documentation and a more advanced understanding of the various elements of the methodology. There can be no legal certainty on the basis of unprecise measurements.*

Before discussing the details of sampling procedures, one should make sure that the analytical measurements on these samples are accurate.

"Lower" statistics means taking a few random samples, analyzing them and finally processing the analytical results by calculating averages and standard deviations. The basic assumption with this procedure is that the deposition is homogeneous and thus that the repeat measurements serve to tackle the analytical error." Higher" statistics mean developing a sampling strategy in the assumption that you don`t know if the deposition has been homogeneous, amongst other arguments. Keywords used in the discussion are the application of Monte Carlo techniques and the like. Reference was made to the very much elaborated sampling procedures applied to determine the chemical composition of a large pile of solid material which has a heterogeneous composition on the micro-scale.

Continuous measurement of a large amount of sampling points is most probably today technically feasible to "capture" the real-world situation of deposition – one could make reference to the "citizens science projects" done in Flanders in the past few years, be it on the content of nitrogen oxides in the air in the cities or the moisture content of the soils. But it is to be feared that the challenge then shifts to mastering and processing the giga-bytes of data.
The target of the measurement is to get data on the full surface of the nature preservation area. Maybe satellite imaging could be used in the future, but then additional parameters would be needed – such as density of the vegetation,… The question arose if the nature preservation area is homogeneous or heterogeneous and what effect that would have on the interpretation of the satellite images.

Deposition measurement is very difficult. Today, only a limited number of measurements are available; maybe an inventory should be made. There is some analogy with measurement of the air quality, where a limited number of validated measurements are used to make the analysis of the real situation. The comment was made on how many measurements you wish to have, which depends on the purpose for which the data are intended to be used. Ideally one should have started like twenty years ago to build up the database.
The comment was made that there is no certified procedure for the measurements. However, it is important to have reliable, correct measurements because the conclusions will affect the future of several citizens. Maybe it is necessary to set up a demonstration project on the measurement.

The comment was made that the models are not reliable, as the wet deposition is weighted with 40%, and the dry deposition with 10%. In Belgium, it seems to rain only 6-7 % of the time.

<u>Statement 2</u>

"Modelling: Ecological systems are so complex that modelling only provides scientifically sound information for interpolation between measurement points. Extrapolation beyond measured points can lead to inaccurate conclusions and should be avoided."

Result: *The participants, although accepting the value of models, raised a lot of questions about the way the current status of mathematics can deal with the ecological and sociological questions that are the key feature of the whole exercise.*

Even in between relevant measurement locations the validity of the model can be challenged. It is important to check and regularly recheck the basic assumptions of the model as compared to reality. Is there a scientific and standardized procedure for deciding which parameters are included in the model? For example, does the model take into account the inundation of the nature preservation area? There are a lot of nitrogen-containing chemicals in the water, but it is very difficult to account for these phenomena. The counterquestion to that was if it is needed to include natural processes such as inundations in a model.

The question was raised: What is the exact meaning of „extrapolation“ and „being outside the model range“? For example, extrapolation over time would not fit in the meaning of the statement, but that is what the European habitat regulation requests. Also, weather conditions are predicted using models, and that prediction has improved considerably over the past twenty years.

The statement uses the keyword "ecology", but there is no ecologist in the audience. The discussion should be repeated with an ecologist. Also, the psychological impact is important.

<u>Statement 3</u>

"Implement: The status of the traction battery of every Tesla driving around the world is centrally monitored. So the technology already exists today to monitor many applications in detail. Without a doubt, it should be possible to monitor the operation of the air purification systems of the stables in Flanders online and reliably, and that is in the interest of everyone and all."

Result: *A strong majority agrees that implementation of continuous and transparent monitoring of all air treatment systems is technically a 'must ' and should be fully established in Flanders for the benefit of the environment.*

The monitoring of the functioning of the air cleaning installations is a part of the air quality 2030 regulation, the data are used by the VLM. The data seem to be kept in a central "location" and are protected against manipulation.

Not only the air composition is recorded, also other parameters need to be monitored (waste water pH,…)
There is substantial research ongoing around the sensors that take measurements in stables. Larger companies will be able to invest in the technology; it will be accounted for in the future construction of stables.

Also the way to implement the consequences of the measurement of the air quality in stables should be given proper attention. For example, if limits for some emissions are included in the permit, it is not obvious for a farmer to stop when there is temporary exceeding, the animals are there to stay. There could be substantial uncertainty, for example, when there is a hot summer,…

The comment was made that the measurement of air quality in stables is a recent evolution, inaccurate numbers are used today.

Economically viable agriculture & rural environment

Statement 1

"Permits, except in a buffer zone, should be emissions-based only."

Result: *Opinions were clearly divided on this question; there appears to be a need to demonstrate that emissions can be objectively defined and to further specify the value of a 'buffer zone'.*

Measuring emissions in agriculture raises questions about 'what, when, and how '. For example: how much 'emission' do you calculate for a bovine which resides part of the time in a stable? Will one then take into account the individual situation of each cattle farm? Several participants thought that measuring emissions objectively was an impossible task.

Buffer zone: there was discussion about the size of the buffer zone and the very principle of a buffer zone. Many felt that creating a buffer zone creates an additional and unnecessary complication. Those who disagreed with the buffer zone voted 'no'.

Statement 2

"The standstill principle is not tenable for small nature areas in densely populated regions."

Result: *The audience had a split opinion: part considers nature as a full priority, part stands for a pragmatic approach and accepts economic activities with impacts on nature, although the latter should be kept as minimal as possible.*

Small nature areas near residential areas will decrease in quality even without any further expansion of economic activity nearby. Therefore, the standstill principle is difficult to maintain in these small areas, and biodiversity may suffer.

Yet, a group of participants argued that biodiversity should be given every priority, even in small natural areas near residential areas.

Statement 3

"Ecological, economic and social interests are insufficiently balanced in the context of biodiversity in Flanders."

Result: *The audience could not come to terms; further elaboration on how much ecology is acceptable under the conditions of Flanders is needed.*

A lot of arguments were raised. It was clarified that a 'yes' to this question meant that the ecological aspects prevail today, and everything else is subordinate to this.

Statement 4

"The additional costs of emission reduction measures should be borne by normal market forces, provided that imports that do not comply with the emission measures are subject to a levy."

Result: *The majority of the attendees believe that normal market forces must be allowed to operate but that there is a need to explore clever mechanisms to inform the consumer so that the farmer can implement the extra costs.*

Most agreed with the principle of market forces, provided that the costs of mitigation measures are passed on to the consumer and that the farmer does not have to bear all the extra costs.

The fact that subsidies are not a good solution was widely supported.

About levies at the external border, people were very sceptical. On the one hand, people felt that levies often do not hold up when 'stronger ' interests are at stake. Examples: the Mercosur Treaty in which agricultural interests had to give way to other economic interests, or the temporary duty-free imports of Ukrainian agricultural products. On the other hand, people wondered how these levies should be regulated at the European level. Since this was a problem essentially limited to Flanders and the Netherlands, many did not believe that one could solve it at the European level. Levies at the Flemish or Dutch border seemed an absurd idea. Others noted that other regions in Europe will be strongly affected by emission reduction measures and that the Flemish problem is not an isolated case after all.

4. Summary: nitrogen, in all fairness

Two international scientists have spent a year examining the nitrogen crisis in Flanders and the Flemish Government's Programmatic Approach to Nitrogen (PAS). The scientists recognize the need for further regulation of nitrogen emissions and deposition in Flanders to meet EU requirements for Special Protection Areas (SBZ-H areas). They accept that SBZ-H restoration should be completed by 2050 and nitrogen deposition should be fully controlled by 2045, as proposed in the PAS report. Broadly speaking, they support the PAS principles, i.e., the use of science-based critical deposition values and the idea of basing a permit policy for agriculture on impact scores. The impact scores are calculated from the ratio of modelled depositions to critical deposition values.

However, external scientists consider PAS too strict. For example, they find that the PAS principles (the deposition policy) should *not* be applied to industry because NO_x emissions are decreasing and because the best available techniques can be used here as a policy measure. For agriculture, they suggest a slight relaxation of the accepted exceedance, its derivation is based on extreme situations, and it leads to difficult to defend (low) depositions. That relaxation would likely exempt smaller farms, and provide experience for technology development and regulatory adjustments, while ensuring slightly slower implementation and nitrogen deposition reductions. The scientists believe that model-based predictions of nitrogen deposition should be more refined and validated – certainly those at close distances from the source – and more effort should be put into emission reduction technology, both in barn construction, air scrubbing and livestock feeding. The system for approval of existing and new technologies should be better organized and more information should be shared with regions outside Flanders that have similar problems.

The findings were presented by the thinkers on March 5, 2024, to a broad audience of stakeholders and scientists. The afternoon of that day resulted in discussion groups that generally endorsed the above findings. A fundamental discussion was held to convert the PAS deposition policy to an emissions policy. The latter has the advantage that the principle of equality for each farmer or industry is more respected i.e. the location of the emission relative to the SBZ-H plays no role in it. However, the deposition policy is more scientifically defensible while an emission policy may be more socially acceptable. It is advisable to further explore which of the both principles is most fitting.