Science at the core of policy and practice: AERIUS, the calculation tool of the Dutch Integrated Approach to Nitrogen

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Abstract
In northwest Europe deposition of atmospheric nitrogen is one of the main problems to maintain or restore natural habitats into a favourable conservation status. The Integrated Approach to Nitrogen (PAS) of The Netherlands is a national plan combining generic source measures to reduce nitrogen emission levels and ecological restoration measures in Natura 2000 areas, while creating room for economic development. The aim of the PAS is to ensure that conservation goals can be achieved while facilitating further economic development around Natura 2000 areas within strict environmental limits. In this way, the PAS connects economy and ecology. In this paper we will present the PAS and the AERIUS instrument which is built and used to define and watch the environmental limits. Therefore, AERIUS is not only a calculation tool, but also functions as a conceptual framework that was developed according to an innovative approach. An international review panel congratulates the Dutch government with the successful development and implementation of AERIUS.

Key Words
Integrated Approach, Nitrogen, Economy, Ecology, Transparency, Instrumentation, Policy

Introduction

There are two cornerstones that support the Integrated Approach to Nitrogen (PAS) to achieve the Natura 2000 (European Council 1992) nature conservation targets in the Netherlands. In the first place, the PAS is intended to realize a continued reduction in nitrogen deposition under current nitrogen policy. Moreover, in order to achieve further emission reductions, an additional package of agricultural measures has been agreed on for the PAS by both government and stakeholders. The second cornerstone to achieving the nature conservation targets is that of ecological restoration measures in Natura 2000 areas. This may consist of applying sods or hydrological measures to increase the general resilience of local habitats (Koelemeijer 2011).
The philosophy behind the PAS is that of using part of the deposition reduction for the development of economic activities for which permits are required, either new or expansion of current activities. This part of the reduction is what is referred to as *room for development*. In most cases emission reduction is achieved by using lower emission techniques which require innovation and economic growth to make them sustainable and thus room for development (permit licensing) is needed. However, this room for development only will be made available after ecological experts have determined that the projected reduction in deposition in combination with restoration measures will not put the achievement of the Natura 2000 targets at risk. The room for development is calculated per type of habitat, per Natura 2000 area.

The challenge for AERIUS

AERIUS is the PAS' calculation tool. The above-mentioned policy framework presented AERIUS with the challenge of calculating the total nitrogen deposition as well as the amount of room available for nitrogen deposition from new or expansion of current activities. Three issues played an important role:

1. How to ensure that the desired high economic growth is taken into account in deposition calculations for the future, and how to determine which part of this future total deposition could be the 'room for deposition'?
2. How to ensure that such room for deposition becomes available at the locations where it is needed?
3. How to distribute the available room for deposition over the various segments that are distinguished by the PAS?

In order to solve these issues, additional policy choices were made for the implementation of the concept of deposition room, in close collaboration between the AERIUS team and the policy staff of national and

Provincial authorities involved. On this basis, AERIUS Monitor, one of the AERIUS products, was used for making a quantitative and spatial elaboration of the total room for deposition.

Facilitating high economic growth: how does that work?
Results from projections of economic growth in the Netherlands are always within a certain range. The general policy choice for the PAS to offer room for high economic growth has been elaborated by basing deposition calculations on the upper limit of this range. This was done using the CPB growth scenario that is also applied for the projections of large-scale concentrations and deposition of for example nitrogen, used by RIVM to compose the annual GCN/GDN maps (maps of large-scale concentrations and deposition in the Netherlands) (Velders 2015). This scenario, also called the 'upper-range policy projection', is based on a high economic growth of 2.5% and on the implementation of current and proposed nitrogen policy.

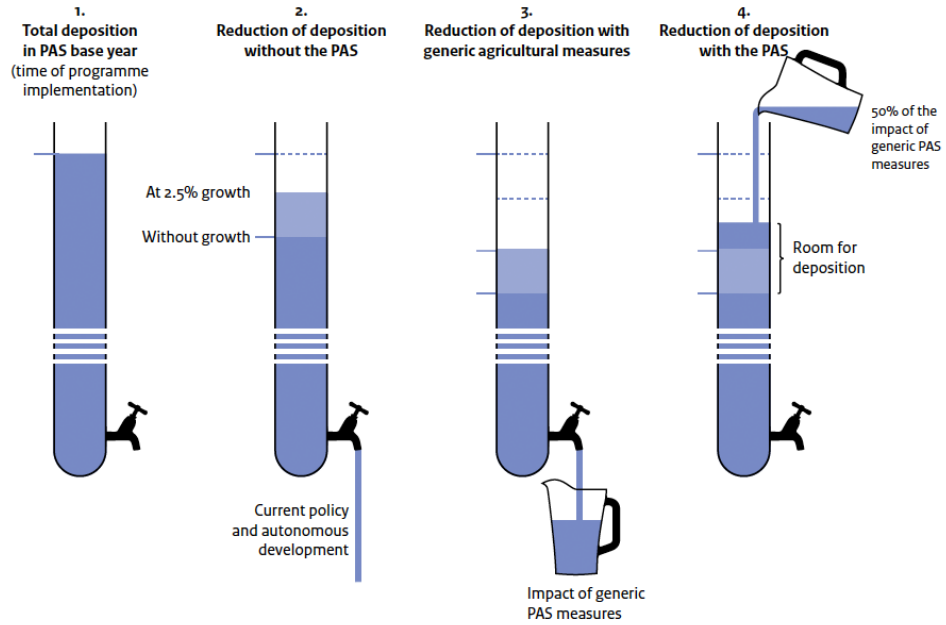

Figure 1. Definition of the room for development as part of the total annual deposition levels.

Under the high growth scenario, deposition will decline overtime; emission reductions due to current environmental policy and innovations in the economic sectors are larger than emission increases due to economic growth. This is shown in Figure 1 by the first two tubes. The second tube is less full than the first; deposition has gone down over time, despite the projected high economic growth. Part of the future deposition under the high growth scenario consists of contributions to deposition that result from new or expanding economic activities. This is the so-called growth share within the total future deposition. This growth share can be allocated as room for deposition. In order to determine the size of this growth share, AERIUS has calculated a hypothetical growth scenario of 0% growth. Under this 0% scenario, the deposition level is lower than under the high growth scenario. This lower deposition level is indicated by the additional line ('without growth') in the second tube of Figure 1. The difference between this line and the one that belongs to 2.5% growth is the growth share. Because the PAS involves the implementation of additional source measures in agriculture, deposition levels will go down even further. This is illustrated by the third tube; the additional PAS measures cause a further drop in the content of this tube. Half of this reduction will be made available as room for deposition for new developments. This is illustrated by the fourth tube, which is filled with half of the additional reduction, which thus shows the end result, with the upper part of the tube representing the total room for deposition that is made available under the PAS (Maltha, Heer, Wilmot, 2015).

Distributing the room for deposition
The calculated room for deposition applies to all new developments together, if they were all already implemented at the same time. The PAS distributes this room over four 'segments'. This distribution is also calculated by AERIUS (Figure 2). Calculations are carried out on a hectare level; thus, the distribution over the four segments can differ per hectare.
The frst part of the room for deposition concerns an amount reserved for developments that cannot be managed; the autonomous developments, such as population growth (more household emissions) and

increases in traffic volume. In AERIUS, this reserved amount equals the expected growth in emissions from the so-called autonomous sectors.
The second part of the room for deposition is reserved for all developments with a deposition below the limit value of 1 mole/ha/year, as set by policy, and therefore only require submission of a so-called notification. In order to determine the reserved amount of development room below the limit value should be, AERIUS uses calculation results from so-called high priority projects (see below) and a rule of thumb for all other developments. The rule of thumb is based on an analysis of existing permit applications and means that 30% of the total expected desired growth that is neither autonomous nor high priority will be reserved for developments below the limit value.

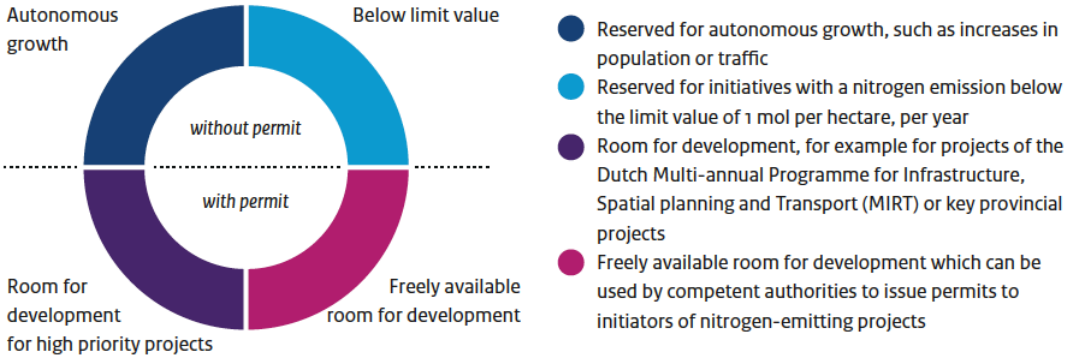

Figure 2. Distribution of the room of deposition over four segments.

The remaining room for deposition is the so-called room for development under the PAS: the share of the deposition room that is available for new or expanded activities that require a permit. Part of this room for development is reserved for so-called high priority projects ('Segment 1'). These, for example, are large infrastructural government projects or key provincial projects. AERIUS determines the size of this reservation on the basis of the calculated deposition contributions by the high priority projects. The share that remains is the freely available room for development ('Segment 2').

Stakeholder management
An important issue for the initiators of projects involving nitrogen emissions is that of obtaining a permit for their planned activities. In other words: how they could use the available room for development. This question remains the central issue in the development of AERIUS Calculator. For a 100% correlation with user needs and in order to arrive at a true practical tool, the AERIUS development team chose the UCD (user-centered design) approach.
According to the UCD design philosophy, a product is optimized around the way users wish, can or must use that product. This in contrast to approaches that force users to adjust their behavior to suit the product. In *user-centered design*, ICT is maximally applied to provide solutions and serve the users' wishes and needs. This approach means that AERIUS development goes much further than merely addressing a 'modelling issue' around nitrogen dispersion.
A working group of around 15 future users was set up, consisting of business community representatives, permit issuing officials and competent authority experts. This working group formulates the desired functionality of the model and its preconditions. Each month, the AERIUS development team demonstrates a working version of the calculation tool to the working group. The users check the progress and provide feedback. During these sessions, users also identify and prioritize the development team's workload for the following month. They therefore not only participate in the discussions, but also share in responsibilities related to the development of AERIUS.
The main result of this approach is that data is transformed into information. The particular information to be entered into the calculation tool matches the user's knowledge and everyday reality. This also applies to results and the way in which these are presented, in relation to the user's final questions. The tool not only presents data, it also provides meaning. Initiators could for example use AERIUS to explore whether and in which variant their projects would be eligible to receive a permit related to nitrogen.

Science under the hood
As indicated above, the core of the AERIUS calculation tool consists of the Operational Priority Substances (OPS) model. Since the 1990s, the OPS model has been leading, in the Netherlands, in modelling large-scale

dispersion of nitrogen from various individual sources. The model is owned by the Dutch National Institute for Public Health and the Environment (RIVM) and PBL Netherlands Environmental Assessment Agency. OPS uses what is known as a Gaussian plume model to calculate local-scale dispersion of NH_3 and NO_x. For dispersion over relatively larger distances (more than 20 kilometres), OPS operates as a trajectory model. In this way, contributions from local, regional and foreign sources may be combined within one calculation.

Meaningful results

Calculations subsequently result in a map of nitrogen deposition, which is then combined with the map of Natura 2000 areas as available in AERIUS and the nitrogen-sensitive habitats within them. This immediately shows the areas and habitats affected by a particular project.

AERIUS also contains data on background deposition, based on emission data derived from the Pollutant Release and Transfer Register which is also used for drawing the RIVM map on long-range transboundary air pollution in the Netherlands. AERIUS also contains data on critical loads of deposition for each type of habitat. AERIUS adds together the calculated amount of project-related deposition and the background deposition, and subsequently shows, per location, the total deposition in relation to the critical load. For ecologists, this is crucial information to assess the situation.

Results

In 2015 AERIUS has been subject to an international review to determine the scientific value of the instrument as well as asses how fit for purpose it was. While incremental enhancements where evidently suggested the review committee congratulated the Dutch government on the realization of this comprehensive instrument. Which creates insight in the relevance of nitrogen deposition for all professions e.g. nature conservation, policymaking, legislation and permits issuing (Sutton 2015). This can be seen in Figure 3.

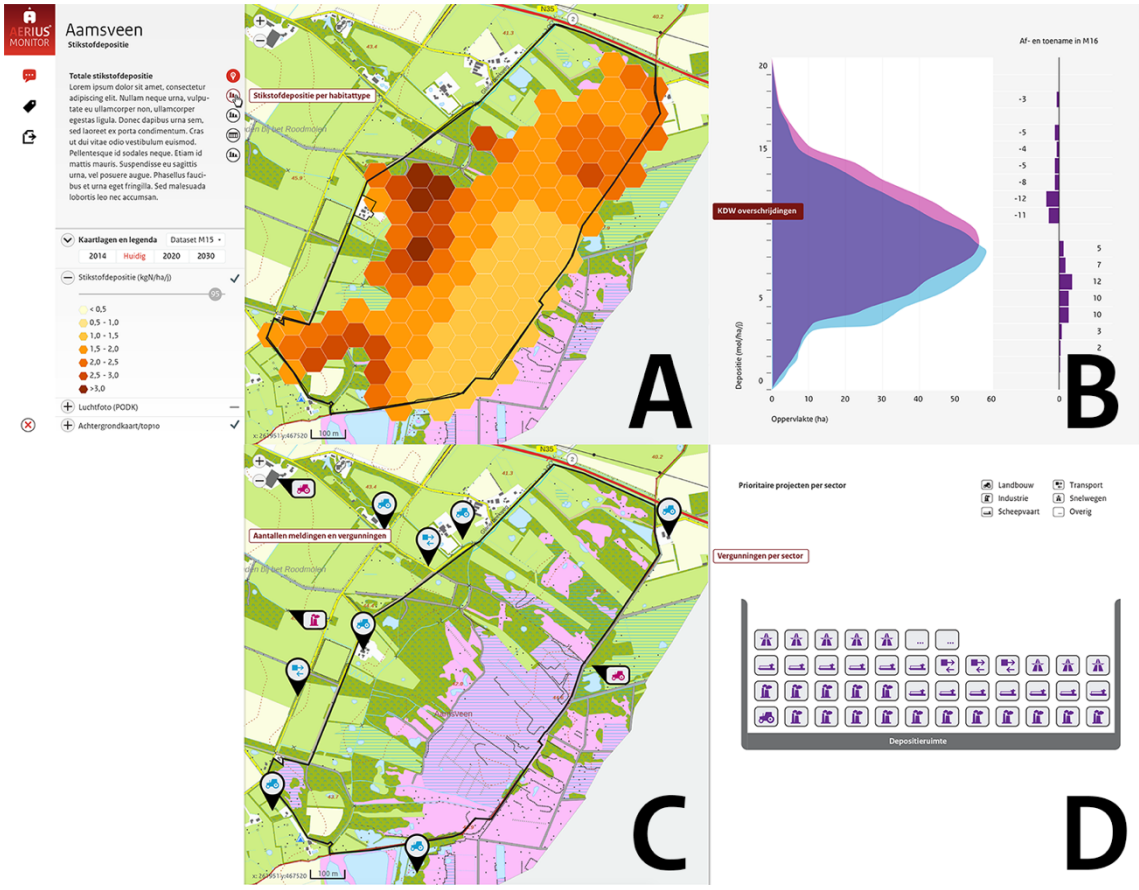

Figure 3. Examples of various presentation formats in AERIUS. Nitrogen deposition in relation to nature (A and B). Permits issuing and assertion (C). Room for development for policy makers (D).

Due to the information presented by AERIUS within the Integrated Approach to Nitrogen. More than 200M euros are allocated to take ecological restoration measures, around 5000 permits are issued since it's stars in July 2015 and the public debate turned from repressive contradictions to opportunities.

Conclusion

The PAS is a *complete* programme that encompasses governance levels, nature areas and economic sectors. This, therefore, called for a completely new and truly integral support tool. The development of this tool set many things in motion. In the first place, AERIUS was the catalyst in the development of one national map of habitats for Natura 2000 areas. In addition, a new, standard calculation method was developed for nitrogen emissions from mobile sources. Furthermore, the development of AERIUS also led to the standardization of emission factors, such as for sea shipping. Information on land use, which is important in dispersion calculations, could be made more location-specific than before, using new more powerful calculation technology. All this was united within one tool which will be made available, online, to everyone. With the introduction of this tool it is clear to all entrepreneurs how to substantiate their permit applications. As it helps Policymakers to optimize policy and legislation while ecologists use the system to locate and research effects of excessive nitrogen deposition on habitats and impact of ecological restoration measures.

The AERIUS products, together, form a cohesive set of tools to map and monitor the room for development in relation to nitrogen deposition in Natura 2000 areas, on national, regional and local scales. Thus, AERIUS is not only a calculation tool, but also functions as a conceptual framework that was developed according to an innovative approach.

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