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Biodiversity Impacts and Offsetting Costs of Nitrogen Deposition

A PROTOCOL THAT ENABLES NITROGEN DEPOSITING BUSINESSES TO ASSESS THEIR RESULTING IMPACT ON BIODIVERSITY AND THE BIODIVERSITY OFFSETTING COSTS FOR WHICH THEY ARE RESPONSIBLE

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ABSTRACT

Biodiversity loss is currently one of the most important environmental issues worldwide, alongside and interlinked with climate change. Nitrogen (N) deposition is forecasted to be in the top three drivers for change in global biodiversity by the year 2100, together with land use and climate change. Creating a practical tool that enables businesses to identify their main impacts on biodiversity is a major challenge. In this study, a protocol was developed to assess the impacts on biodiversity as a result of N deposition caused by business activities. More specifically, the impact at habitat types and species in Natura 2000 sites is reviewed. The protocol takes into account the exceedance of the critical deposition load by the background deposition, as well as the share for which the company is responsible. Furthermore, a method is proposed to capitalize biodiversity offsetting measures, based on the costs that would be associated with the construction of new nature. This way, a budget can be defined that should be deployed in a cost-effective way to reduce the negative biodiversity impacts from N deposition. The protocol was tested by applying it to N emissions from four electricity and heat producing power plants, operated by Eneco. Eneco was found to be responsible for a total of 23 ha at which species and habitats were negatively impacted in 2015. These hectares are distributed over many different types of habitats throughout the Netherlands. The biodiversity offsetting costs of N deposition from electricity and heat production by Eneco were found to be € 60,662 for 2015.

Key words: background deposition; biodiversity; capitalization; critical deposition load; impact assessment; nitrogen; nitrogen deposition; offsetting

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PREFACE

This research was carried out at Eneco over a period of 5 months. Eneco is an energy generating company providing services in the Netherlands, Belgium, Germany, France and the United Kingdom. As part of its sustainability strategy (One Planet Thinking), Eneco wants to develop a scientifically sound methodology to determine its performance in the field of biodiversity impacts. This research was submitted in partial fulfillment of the requirements for the degree of Master of Science in Energy Sciences at Utrecht University.

I would like to thank the following people, without whose help and support this research would not have been possible. I would like to show my gratitude to dr. René Verburg, lecturer, researcher and my 1st assessor at Utrecht University; dr. Pita Verweij, assistant professor and my 2nd assessor at Utrecht University; and Gerben Meijer, my supervisor at Eneco, for their valuable insights and directions throughout this research. I would also like to thank the directors and environmental experts of the power plants that participated in the case studies for sharing their information and knowledge in this field.

EXECUTIVE SUMMARY

In this study, a protocol was developed to assess the impacts on biodiversity as a result of nitrogen (N) deposition caused by business activities. More specifically, the impact at habitat types and species in Natura 2000 sites was reviewed. Furthermore, a method was proposed to determine the biodiversity offsetting costs of N deposition for which the business is responsible. The methodology was tested by applying it to N emissions from electricity and heat producing gas and biomass power plants, operated by Eneco.

Biodiversity loss is currently one of the most important environmental issues worldwide, alongside and interlinked with climate change. Sala et al. (2000) forecasted N deposition to be in the top three drivers for change in global biodiversity by the year 2100, together with land use and climate change. Food and energy production have caused a serious increase in atmospheric N deposition over the last century, resulting in increased N availability for ecosystems (Braakhekke et al., 2015). This stimulates the production of biomass and thereby hinders maintaining or developing a favourable conservation status for these ecosystems, which are mostly N limited (Bobbink, Bal, et al., 2002). This poses a serious threat to biodiversity (Bobbink et al., 2010). The need for a greater global approach to assessing N deposition impacts was also emphasized by Phoenix et al. (2006).

Protocol

The protocol that was developed in this study consists of seven steps, that aim to assess the impacts on biodiversity as a result of N deposition caused by business activities, as well as the associated biodiversity offsetting costs. The assumptions that had to be taken to create a universal approach are numbered in this section as footnotes.

Protocol for biodiversity impact assessment of N deposition

1. Scoping	Determine the load, heat content, location and height of the N emissions for the applicable system boundaries.
2. Impact area	Insert outputs step 1 into AERIUS[1] to calculate the N deposition at habitat types[2] in Natura 2000 sites up to 0.05 mole N ha^{-1} yr^{-1}.
3. Current N deposition	For the affected habitat types, determine the total background deposition (BD) and the share of Dutch sectors in this.
4. Habitats & Species	For the affected habitat types, determine the critical deposition load (CDL), the conservation status and the surface area. For the species[3] present at these habitat types, determine their conservation status.
5. Biodiversity effects	Determine the biodiversity effect in terms of a) impacted hectares [ha], b) # impacted Natura 2000 sites, c) # impacted unique habitat types, and d) # impacted unique species. Two criteria apply: 1) N deposition > 1 mole N ha^{-1} yr^{-1} [4]

[1] In the Netherlands AERIUS Calculator is used to calculate N deposition at Natura 2000 sites from NO_x and NH_3 emissions (Ministry of Economic Affairs, 2015a). Appendix A further elaborates on the characteristics of this software.
[2] Only N sensitive habitat types are taken into account, i.e. critical deposition load ≤2,400 mole N ha^{-1} yr^{-1} (Van Dobben et al., 2012).
[3] Only species are reviewed that are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and are dependent on N sensitive habitat types (AERIUS, 2015).
[4] The general deposition limit is 1 mole N ha^{-1} yr^{-1}, based on the Programmatic Approach to Nitrogen (PAS) (Dutch Government, 2015). For Dutch Natura 2000 sites that already suffer from high N deposition (PAS-bureau, 2016) the deposition limit is lowered to 0.05 mole N ha^{-1} yr^{-1} (Dutch Government, 2015; Jasper et al., 2010).

6. Responsible share

2) BD > CDL [5]

Determine the area of habitat types for which the company is responsible to compensate, taking into account the exceedance of the CDL by the BD (i.e. the compensation factor) and the responsible share of the company in the total deposition[6].

7. Capitalizing biodiversity offsetting

Determine the biodiversity offsetting costs that would be associated with constructing the affected nature types elsewhere by means of compensation. This gives an annual budget that should be deployed by the company to reduce the negative impacts from its N deposition.

Results

This protocol was applied to four electricity and heat producing power plants of Eneco. In 2015, the power plants of Lage Weide, Merwedekanaal, Enecogen and Bio Golden Raand have together produced 4,368,693 MWh electricity, causing 764,108 kg NO_x and 2,451 kg NH_3 emissions in the production phase (Eneco, 2015). The resulting N deposition caused a contribution to a negative impact at the following biodiversity values (Step 1-5):

	Lage Weide	Merwedekanaal	Enecogen	Bio Golden Raand
Hectares	24,643	21,085	22,947	0
Natura2000 sites	11	6	12	0
Habitat types	35	28	41	0
Species	22	16	22	0

Determining the total area for which species and habitat types should be compensated by Eneco (Step 6) and the biodiversity offsetting costs of N deposition (Step 7), gives the following result for 2015. This area and offsetting cost are the sum of all individually affected habitat types, and should be interpreted as such.

	Lage Weide	Merwedekanaal	Enecogen	Bio Golden Raand
ha Total area for which species and habitat types should be compensated by Eneco in 2015	13	4	5	0
€ / yr Biodiversity offsetting costs of N deposition from electricity and heat production by Eneco in 2015	35,952	11,757	12,953	0

[5] If BD > CDL, the possibility exists that the conservation status of habitats and species is negatively impacted by the additional N deposition from the company (Van Dobben et al., 2012).

[6] The share of the impact for which individual stakeholders are responsible was calculated by dividing their deposition by the part of the total N deposition that can be explained by emissions from Dutch sectors (Megens, 2016), since these emissions could be explained with the highest level of certainty and allow for assigning responsible parties their share in the total impact (Ministry of Economic Affairs, 2015b).

The contribution from Bio Golden Raand to a negative biodiversity impact in Natura 2000 sites was found to be negligible. The electricity production as well as the emissions from Bio Golden Raand were significantly lower than from the other power plants. To give an idea of this difference, NO_x emissions from Bio Golden Raand were only 7-17% of the NO_x emissions from the other three plants in 2015. Besides, in none of the Dutch Natura 2000 sites where N deposition from Bio Golden Raand takes place, BD > CDL. According to Assumption 5, it was therefore assumed that the conservation status of habitats and species is not directly negatively impacted by the additional N deposition due to electricity and heat production by Bio Golden Raand. As a consequence, no compensation would be required in 2015 by Bio Golden Raand.

Another thing that stands out is that although the amount of hectares and habitat types at which Lage Weide, Merwedekanaal and Enecogen contribute to a negative impact (Step 5) are relatively similar, the area to compensate (Step 6) and the biodiversity offsetting costs (Step 7) for Lage Weide are about three times higher than for the other two. These differences can be explained by three factors. To start, the average deposition share at the Natura 2000 sites in 2015 is the highest for Lage Weide. Secondly, for Lage Weide it occurred more often that the relatively higher deposition shares were situated in habitat types with comparatively larger surface areas. And thirdly, the exceedance of the CDL by the BD was found to be relatively larger at most habitat types where Lage Weide deposited nitrogen. This resulted in a higher overall contribution and therefore a larger area for which species and habitat types should be compensated by Lage Weide in 2015.

Discussion & Recommendations

In contrast to other biodiversity impact assessment methods (Goedkoop, Heijungs, De Schryver, Struijs, & van Zelm, 2013; Lammerant et al., 2016; PBL, 2016; Steffen et al., 2015) this protocol provides the opportunity of expressing the absolute impact of an individual company's N deposition at biodiversity. Besides, an innovative method is proposed to translate this responsible impact into an annual compensation budget that reflects the biodiversity offsetting costs of N deposition.

However, some limitations of the protocol require further research. Primarily, for pragmatic reasons the current protocol only reviews the impact of N deposition at Natura 2000 sites [Assumption 1] and for species designated under the Birds and/or Habitats directives [Assumption 2]. In reality, off course, also nature and species which are not included in these directives suffer from negative biodiversity effects of N deposition. Secondly, for the purposes of this study it was decided to use the deposition limit above which the Dutch legislation requires projects to have a permit [Assumption 4]. Extensive research on N deposition effects on habitat types and species might provide the possibility to define habitat-specific deposition limits. This would require combining the CDL of habitat types with their conservation status at specific Natura 2000 sites. Using such habitat-specific deposition limits would be preferred over aligning the limit with legislation, since this increases the level of certainty of calculated and/or measured biodiversity effects of N deposition. Furthermore, this study has only taken into account the operational phase of Eneco's power plants. In practice, however, N emissions also take place during other activities throughout the supply chain, e.g. during transport and sourcing of the fuel. It is recommended to further develop N deposition modeling software in order to also include the effects of these emissions. Subsequently, it is recommended to expand the protocol with a cost-effectivity analysis, that identifies the most effective compensation measure(s) based on the characteristics and conservation status of the affected sites. This would allow for deploying the biodiversity offsetting budget in the most cost-effective way. In reality, an expert opinion will still be required to determine what is the best option for the different affected habitat types. On the whole, it is proposed to expand the protocol by including other pressure factors that influence biodiversity. Relevant pressure factors in the energy sector are noise and light emissions and barrier / collision effects. Expanding the protocol by adding a larger amount of pressure factors would make it possible to more accurately determine the total biodiversity impacts, as well as applying the protocol to other sectors. In this light, further research is proposed on effects of correlating and combined pressures, whether these effects take place at local, regional or global level, to what extent cumulation plays a role in this and the relative sensitivity of species and habitats to these pressures.

Conclusion

Taking the relative exceedance of the CDL and the deposition share of Eneco in all habitat types into account, Eneco was responsible for a total of 23 ha at which species and habitats were negatively impacted in 2015. These hectares are distributed over many different types of habitats throughout the Netherlands. In the light of OPT, Eneco wishes to compensate for its negative impacts on the environment. The biodiversity offsetting costs of N deposition from electricity and heat production by Eneco were found to be € 60,662 for 2015. This budget is based on the costs that would be associated to the construction of new nature, taking into account the characteristics of the different affected habitat types. These costs will return on a yearly basis, assuming constant efficiency and production. The budget should be deployed in a cost-effective way to reduce the negative biodiversity impacts from N deposition and to maintain or improve the conservation status of the affected Natura 2000 site(s). The most cost-effective compensation measure should be applied first, while giving preference to the habitat types and species that have an unfavourable conservation status. Further research is recommended to provide detailed guidelines on how this should be accomplished in practice.

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ANK	Atlas Natuurlijk Kapitaal (Atlas for Natural Capital)
BGR	Bio Golden Raand (Power plant Eneco, Farmsum)
BD	background deposition
CBD	Convention on Biological Diversity
CCGT	combined cycle gas turbine
CDL	critical deposition load
CO_2	carbon dioxide
CS	conservation status
EG	Enecogen (Power plant Eneco, Rotterdam)
E/MSY	extinctions per million species-years
EU	European Union
F	favourable (CS species)
FV	favourable (CS habitats)
ha	hectare
kg	kilogram
LW	Lage Weide (Power plant Eneco, Utrecht)
MK	Merwedekanaal (Power plant Eneco, Utrecht)
MU	moderately unfavourable (CS species)
MWh	megawatt hour
N	nitrogen
NH_3	ammonia
N2K	Natura 2000
NNL	No Net Loss
N_2O	nitrous oxide
NO_x	nitrogen-x-oxide
OPT	One Planet Thinking
PAS	Programma Aanpak Stikstof (Programmatic Approach to Nitrogen)
TWh	terawatt hour
U1	unfavourable-inadequate (CS habitats)
U2	unfavourable-bad (CS habitats)
UN	United Nations
VU	very unfavourable (CS species)
yr	year

1. INTRODUCTION

Biodiversity loss is currently one of the most important environmental issues worldwide, alongside and interlinked with climate change. Biodiversity is part of our natural capital, providing ecosystem services that support our economy and society (European Commission, 2011; Rijksoverheid, 2014). Biodiversity loss thus is about to become a major concern to businesses, given the fact that while they rely on the natural capital for their business activities, they also considerably contribute to its loss (De Bie & Wiltink, 2015). With this in mind, many businesses nowadays incorporate a corporate sustainability strategy to lower the impact of their activities on the environment (Kerkhof, De Boer, Meijer, Scheepmaker, & Blok, 2015).

Eneco works within the context of One Planet Thinking (OPT) as part of their corporate sustainability strategy. OPT is a science-based methodology that aims to operate within the planetary boundaries of the Earth (Rockström et al., 2009; Steffen et al., 2015), and is jointly developed by the Worldwide Fund for Nature (WWF), Ecofys and Eneco (Eneco, Ecofys, & WWF, 2016). It is the vision of OPT that a world is needed in which people live in balance with nature, thereby ensuring the sustainability of humanity and all life on Earth. Companies should develop strategies and formulate targets and actions such that they can operate within safe limits (i.e. planetary boundaries) of the Earth's systems. Incorporating OPT can give companies insight in their impact on biodiversity. The impact should be related to the local, regional and international environmental situation, type of landscape and its environmental boundaries (Eneco, 2014).

To date, the planetary boundaries for climate change, biodiversity, nitrogen and phosphorus cycles and land-system change have already been exceeded (Rockström et al., 2009; Steffen et al., 2015). Determining the level of exceedance of the planetary boundary for biodiversity is however found to be very difficult, as biodiversity is at loss due to a combination of environmental impacts without a known (global) threshold (Mace et al., 2014). Sala et al. (2000) forecasted nitrogen (N) deposition to be in the top three drivers for change in global biodiversity by the year 2100, together with land use and climate change. In 2012, the total NO_x emissions in the Netherlands were found to be 250 Gg (Jimmink et al., 2014). Food and energy production have caused a serious increase in atmospheric N deposition over the last century, resulting in increased N availability for ecosystems (Braakhekke et al., 2015). This stimulates the production of biomass and thereby hinders maintaining or developing a favourable conservation status for these ecosystems, which are mostly N limited (Bobbink, Bal, et al., 2002). This poses a serious threat to biodiversity (Bobbink et al., 2010). The need for a greater global approach to assessing N deposition impacts was also emphasized by Phoenix et al. (2006).

Creating a practical tool that enables businesses to identify their main impacts on biodiversity is a major challenge (Croezen, Head, Bergsma, Odegard, & De Bie, 2014). Lammerant et al. (2016) developed a process to assess biodiversity impacts at a regional or local scale in terms of the associated planetary boundaries. They also considered N emissions. In this study the methodology is further developed and fine-tuned to assess the impacts on biodiversity as a result of N deposition caused by individual business activities. For pragmatic reasons, the protocol is limited to reviewing the impact at habitat types and species in Natura 2000 sites (Ministry of Economic Affairs, 2015c). Furthermore, an innovative method is proposed to capitalize biodiversity offsetting measures by exploring the costs of new nature construction. This way, a budget can be defined that should be deployed by the company in a cost-effective way to reduce its negative biodiversity impacts from N deposition. Eneco also has N emissions associated to their operational activities. The methodology is tested by applying it to N emissions from electricity and heat producing gas and biomass power plants, operated by Eneco. The main research question is:

What are the biodiversity impacts in Natura 2000 sites as a result of nitrogen deposition due to electricity and heat production in gas and biomass power plants, and what are the associated biodiversity offsetting costs (in €/yr)?

The research can be subdivided into three parts, corresponding with the following sub-questions:

- Determining the affected area, habitat types and species to which Eneco contributes as a result of its N emissions:

  What was the total area of Natura 2000 sites (in ha) with a negative biodiversity impact and how many habitat types and species were negatively impacted in this area as a result of nitrogen deposition, to which Eneco contributed due to electricity and heat production in its gas and biomass power plants in 2015?

- Determining the affected area for which Eneco is responsible to compensate as a result of its N emissions:

  What was the responsible share of Eneco (in ha) of the total area of habitat types within Natura 2000 sites with a negative biodiversity impact as a result of nitrogen deposition, due to electricity and heat production in its gas and biomass power plants in 2015?

- Assuming that measures for avoidance and mitigation of the impact have been taken already, the affected area requires offsetting. The last part is therefore capitalization of biodiversity offsetting for which Eneco is responsible, to define a budget that should be deployed by Eneco in a cost-effective way to reduce its negative biodiversity impacts as a result of its N emissions:

  How can capitalization of biodiversity offsetting be used to define a budget (in €/yr) for reducing negative biodiversity impacts from nitrogen deposition in Natura 2000 sites due to electricity and heat production in gas and biomass power plants of Eneco in 2015?

This study is structured as follows. Chapter 2 introduces a theoretical framework that provides more insight into the concept of biodiversity, the Planetary Boundaries framework, biodiversity impact assessment methods, the nitrogen cycles that are present on Earth and relevant legislation. Chapter 3 elaborates on the methodology that is used to carry out the research. A 7-step protocol is introduced to determine the impacts on biodiversity in Natura 2000 sites as a result of N deposition due to electricity and heat production in gas and biomass power plants, as well as the biodiversity offsetting costs associated to this. The results are presented and subjected to a sensitivity analysis in Chapter 4. Chapter 5 provides a discussion of the results, followed by a discussion of the position of this research within international literature, the limitations of this research and lastly recommendations for further research are provided. Finally, Chapter 6 presents the conclusions of the research by answering the research questions.

2. THEORETICAL FRAMEWORK

2.1. Biodiversity

A globally applied and accepted definition of biodiversity is from the United Nations (UN) Convention on Biological Diversity (CBD). The CBD defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Article 2 (Convention on Biological Diversity, 2005)). In the context of biodiversity, habitat refers to the type of site where a species, i.e. a specific organism or population, naturally occurs (Convention on Biological Diversity, 2005). Biodiversity is part of a larger system, i.e. the ecosystem. Within this ecosystem, living organisms interact with their non-living environment (e.g. soil, water, air). Ecosystems provide society with numerous benefits, called ecosystem services. These include (1) provisioning services or products, e.g. food, water, wood; (2) regulating services or processes, e.g. water purification, climate regulation; (3) cultural services, or non-material benefits, e.g. recreation, education, aesthetics; and (4) supporting services that maintain all other services, e.g. nutrient cycling, soil formation, primary production (Millennium Ecosystem Assessment, 2005).

Companies use ecosystem services, depending on their scale, location and supply chain (Croezen et al., 2014). This is mainly the case for companies that are active in the primary sector. Their activities influence biodiversity and ecosystems by using resources (e.g. raw materials, water, land and living materials) and discharging products, emissions and waste streams (De Bie & Wiltink, 2015). A selection of these so-called pressures that businesses exert on their environment are listed in the middle column of Figure 2-1. The pressures can lead to specific impacts on biodiversity and ecosystems, as listed on the left, occurring at the local, regional or global level, as displayed on the right of the figure (Ohm, 2015). The relationship between these factors is illustrated in Figure 2-2.

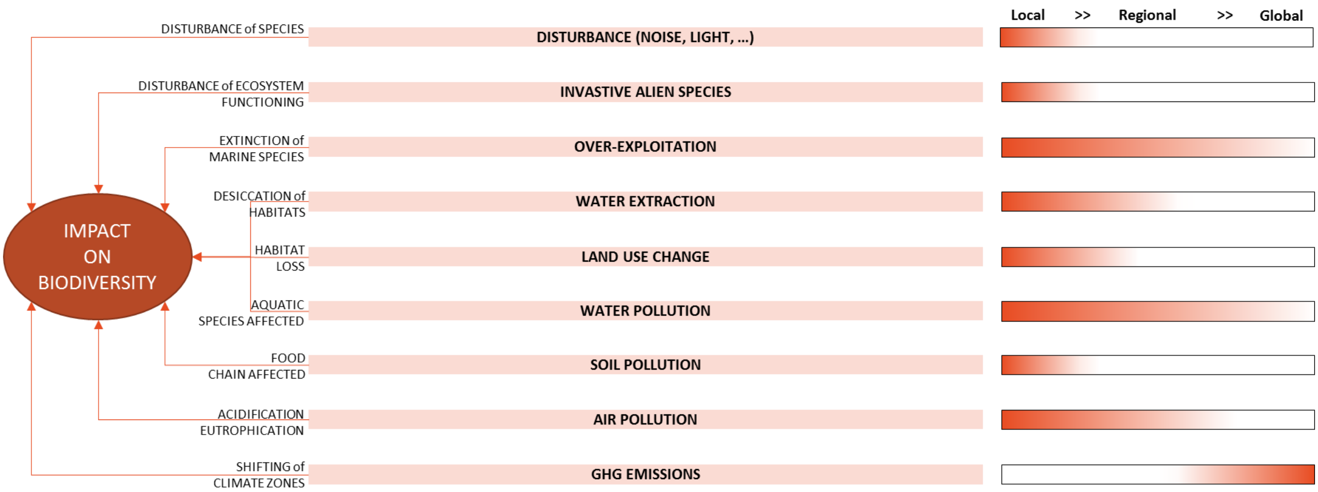


Figure 2-1: Pressures caused by business activities (middle) and their associated impacts on biodiversity (left), occurring at the local, regional or global level (right). Adapted from (Ohm, 2015).

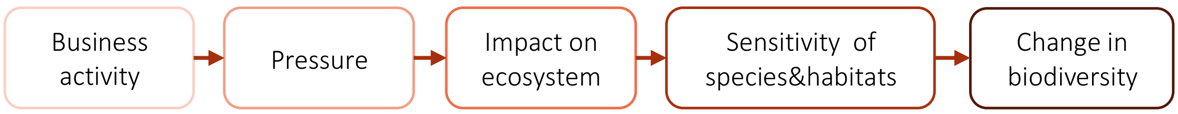


Figure 2-2: Schematic illustration of the relationship between business activity, pressures, impacts and biodiversity change.

2.2. Biodiversity Impact Assessment

2.2.1. PLANETARY BOUNDARIES

The Planetary Boundaries framework provides insight in the current state of the Earth and the risk that the processes that regulate the stability of the Earth system are brought out of balance (Kerkhof et al., 2015; Steffen et al., 2015). The concept was defined by Rockström et al. (2009) and has been updated in 2015 by Steffen et al. Nine planetary boundaries are defined, i.e. at the global scale climate change, ocean acidification and stratospheric ozone depletion; at regional scale biosphere integrity, nitrogen and phosphorus biogeochemical cycles, land-system change, freshwater use and atmospheric aerosol; and novel entities, for which the scale depends on the characteristics of the entity. Steffen et al. (2015) defined novel entities as "new substances, new forms of existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects". It has to be acknowledged that boundaries can be interlinked, e.g. the pressure 'CO_2 emissions' affects both climate change and ocean acidification. To date, the boundaries for climate change, biosphere integrity, nitrogen and phosphorus cycles and land-system change have already been exceeded, see Figure 2-3 (Rockström et al., 2009; Steffen et al., 2015).

Determining the planetary boundary for biosphere integrity (i.e. biodiversity) is however found to be very difficult, as biodiversity is at loss due to a combination of environmental impacts without a known (global) threshold (Mace et al., 2014). An option can be to first determine the boundary of each contributing factor. The biodiversity boundary is currently measured in extinctions per million species-years (E/MSY). The current status is 100-1000 E/MSY. The aspirational goal is ca. 1 E/MSY, which is the background rate of extinction loss, i.e. the standard extinction rate without anthropogenic contributions (Steffen et al., 2015). It is acknowledged that this interim control variable is hard to measure and that room for improvement still remains, but it does offer some guidance until new and better methods become available (Steffen et al., 2015). Other examples of biodiversity indicators to monitor, compare and communicate the state of species, habitats and ecosystems are the IUCN Red List Index (IUCN, 2015), the Living Planet Index (WWF, 2014, 2016) and the European Biodiversity Indicators (European Environment Agency, 2016b).

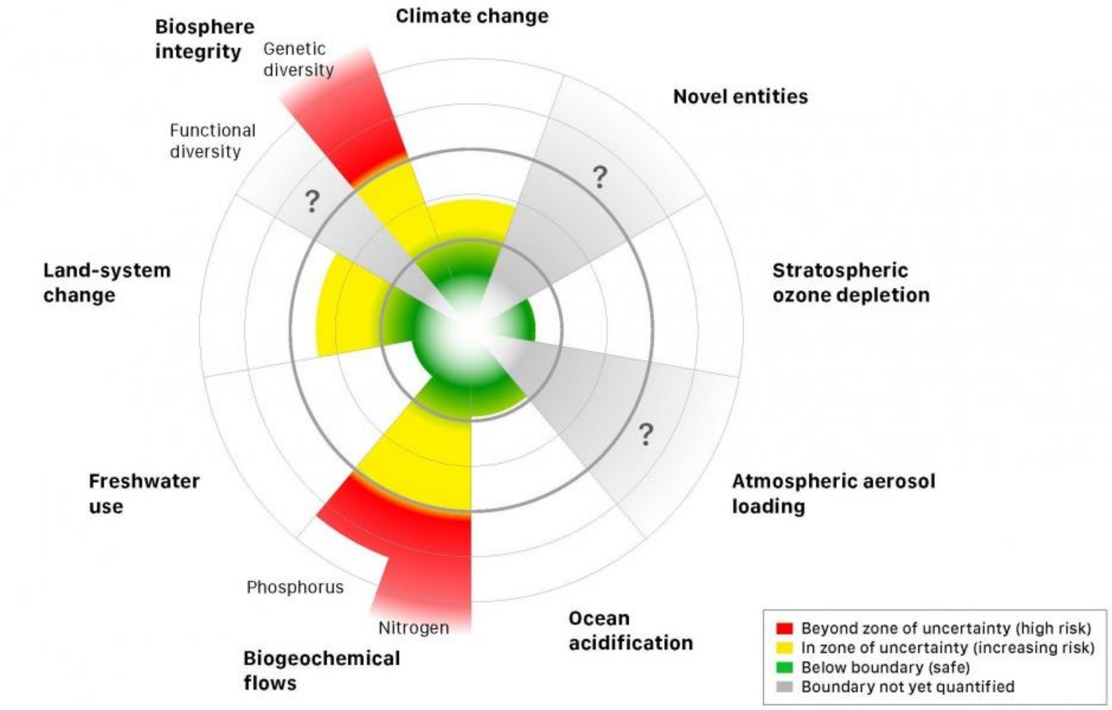


Figure 2-3: Schematic overview of the current status of the planetary boundaries concept (Steffen et al., 2015).

2.2.2 STATE OF THE ART METHODS

The impact of business activities on biodiversity has been subject to research over the past years, which has led to the development of various biodiversity impact assessment methods with different underlying principles (Croezen et al., 2014; Quétier & Lavorel, 2011). It also differs greatly in what way the impacts are expressed and what suggestions are given to offset or compensate for this. The most relevant examples from international literature are provided in the next paragraphs.

Impact assessment methods

Croezen et al. (2014) stated that no practical tool exists that enables businesses to identify their main dependencies and impacts on biodiversity. Two methodologies selected by Croezen et al. (2014) could be relevant for biodiversity impact assessment from N deposition, i.e. the ReCiPe LCA methodology (Goedkoop et al., 2013) and the GLOBIO methodology (PBL, 2016). These were also found to be potentially relevant by Lammerant et al. (2016).

In the Life Cycle Assessment (LCA) ReCiPe 2008 methodology, biodiversity is classified as an endpoint indicator as it is closely related to the three defined endpoint categories, i.e. damage to human health, ecosystem diversity and resource availability. Pressures are linked to impact factors in the same way as shown in Figure 2-1. These are midpoint indicators, i.e. intermediate impacts that all affect biodiversity (Goedkoop et al., 2013). Biodiversity impacts are measured by modeling the dispersion of emissions and dose/effect relations for the species that are found to be exposed to these emissions (Croezen et al., 2014). The main shortcomings of the ReCiPe method are that not all pressures are covered and no clear distinction is made between local, regional and global impacts. Furthermore, ReCiPe does not include data on spatial distribution of species and habitats. These are assumed to be equally distributed within terrestrial, freshwater and marine systems, which is a poor reflection of reality (Lammerant et al., 2016).

The Global Biodiversity model (GLOBIO) is developed by the Netherlands Environmental Assessment Agency (PBL) to assess the impacts and relative importance of anthropogenic environmental drivers on land biodiversity in the past, present and future, allowing for modeling of policy scenarios. The environmental drivers that are included in the model are land use, atmospheric nitrogen deposition, infrastructure, fragmentation and climate change. The biodiversity impacts are expressed in terms of Mean Species Abundance (MSA), defined as “the mean abundance of original species relative to their abundance in undisturbed ecosystems” (PBL, 2016). This indicator expresses both the extent of habitats or ecosystems and the quality of species (Simons & Van Zadelhoff, 2013). The main disadvantage of GLOBIO is that it merely compares policy alternatives and does not give an absolute measure for biodiversity impact (Lammerant et al., 2016). In other words, it does not reflect the total impact on biodiversity as a result of specific business activities (Croezen et al., 2014).

Lammerant et al. (2016) developed a step-by-step process to assess biodiversity impacts at a regional or local scale in terms of the associated planetary boundaries. For pragmatic reasons, the impacts are only measured for Red List species and habitats found in Natura 2000 sites. This demarcation was also proposed by Simon et al. (2013) to help companies to achieve no net loss (NNL) of biodiversity. The impacts are expressed “in terms of exceedance of habitat and species specific thresholds for each pressure factor” (Lammerant et al., 2016). This methodology does however not reflect the biodiversity impacts of individual companies. It only determines in which areas the business activities contribute to a negative biodiversity impact, and then determines the total exceedance of the local biodiversity values in that area.

A methodology that does take into account the impacts and dependencies of individual companies, is the natural capital approach (Natural Capital Coalition, 2016; Spurgeon, 2014). PricewaterhouseCoopers (2013) identified natural capital accounting as “the next big thing in sustainability". This approach is based on the concept of ecosystem services that was explained earlier in this chapter. Nature provides humanity and businesses with services, e.g. air, water, land, materials, energy et cetera (Millennium Ecosystem Assessment, 2005). Natural capital accounting aims to put a monetary value on these services, providing the possibility to consider a company's impacts and dependencies on the environment while doing business. This monetary value then represents the estimated change in value of the ecosystem service to society, as a result of the business activity. An important advantage of this approach is that the impact is expressed into a well-understood metric (money) that allows for comparison. On the other hand, not all impacts can be accurately expressed into a monetary value, potentially leading to different estimates of the same impact (Spurgeon, 2014). The Atlas for Natural Capital (ANK) provides examples of how business should optimally handle natural capital, as well as maps that present the state of ecosystem services throughout the Netherlands. The ANK is developed by PBL, RIVM and WUR, based on the European Biodiversity Strategy (European Commission, 2011) to facilitate the development of a harmonized European approach (PBL, RIVM, & WUR, 2016).

Impact offsetting methods

De Bie et al. (2011) studied possibilities for offsetting compensation of biodiversity impacts to ensure NNL of biodiversity. They define biodiversity compensation as "A set of actions that lead to measurable conservation outcomes, designed to compensate for residual biodiversity impacts that arise from the activities of an existing or new project and that remain after appropriate prevention and mitigation measures have been implemented" (De Bie & Van Schaick, 2011). The compensation plan should include cumulative effects; stakeholder engagement; how NNL is targeted; timing, duration and location of the compensation; and land and user rights. Furthermore, the plan should ensure transparency; that the measures are additional to existing or planned measures; costs are manageable; and feasibility to measure, monitor and report the effectiveness (De Bie & Van Schaick, 2011). The compensation measures are determined on a case by case basis.

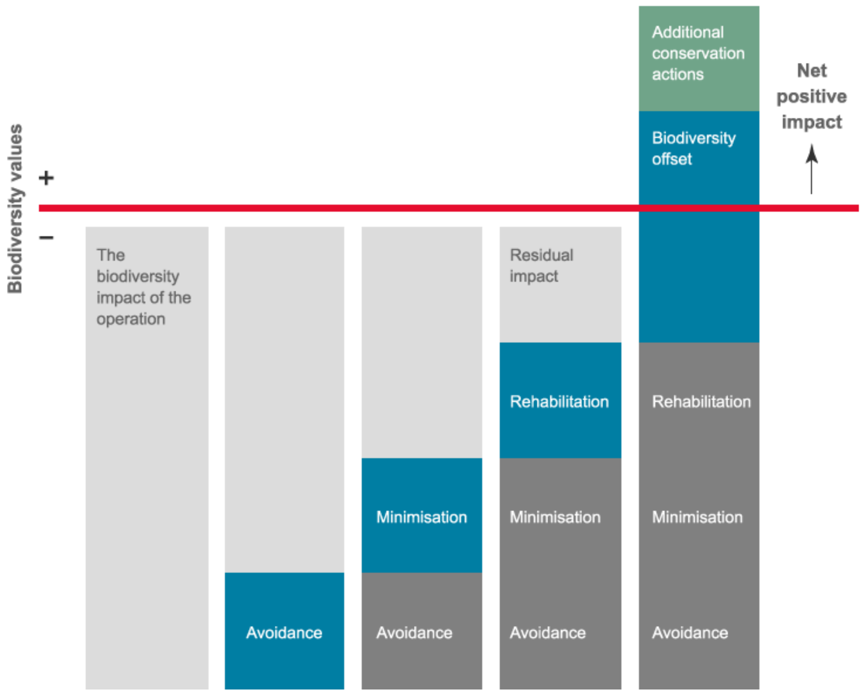


Figure 2-4: Mitigation hierarchy for managing biodiversity risk (Rio Tinto, 2013)**.**

It is agreed that compensation measures are only taken after the company has tried to minimize its impacts, according to the mitigation hierarchy presented in Figure 1-4 (Rio Tinto, 2013). This figure shows that actions should be taken in the following order (PricewaterhouseCoopers, 2010), with regards to N emissions:

- Avoidance: Reducing N emissions as far as possible to prevent N deposition from taking place.
- Mitigation: If avoiding the emissions is not possible on short term, then the negative impacts from N emissions should be minimized.
- Compensation: If both avoidance and mitigation of the N emissions are not possible on short term, actions should be taken with the intention to offset the negative impacts of N deposition. Examples are a rehabilitation or conservation project.

More specifically on compensation measures to offset impacts from N emissions, Schouten et al. (2012) identified a step-by-step approach to reduce N deposition. The order in which the measures take place is based on their cost effectiveness and benefit to nature. Firstly, N deposition is assumed to reduce as a result of companies going out of business. Secondly, generic deposition measures are taken (e.g. reducing emissions from agriculture, industry, traffic by incorporating more efficient processes or other types of technological progression). Local deposition measures are taken as a third step (e.g. relocating agricultural companies, installing air cleansers) and, if the critical load is still exceeded, the last step is to take effect oriented measures (e.g. actively reducing N deposited at nature sites). Measures similar to these should be taken to offset for biodiversity impacts from a business activity, and achieve NNL of biodiversity.

2.3. Nitrogen deposition

The nitrogen (N) cycles of ecosystems originally comprise three main processes: biological N fixation, mineralization, and atmospheric deposition. Biological N fixation allows for introduction of new reactive N within a system, mineralization is the conversion of organic reactive N into inorganic reactive N within a system, and atmospheric deposition transfers reactive N from one system to another (Bobbink et al., 2010). The broad definition of reactive N includes biologically and radiatively active as well as photochemically reactive N compounds present on Earth, i.e. inorganic oxidized forms of N (e.g. NO_x, HNO_3, N_2O, NO_3), inorganic reduced forms (e.g. NH_3, NH_4^+), and organic compounds (e.g. urea, amines, proteins, nucleic acids) (Galloway et al., 2004).

Over the last decades atmospheric deposition has developed from a relatively unimportant N source to the dominant N source, as a result of anthropogenic emissions (Bobbink et al., 2010). Figure 2-5 shows that between 1860 and 2005 global anthropogenic creation of reactive N has increased from ~15 Tg N yr^{-1} to ~190 Tg N yr^{-1} and per capita reactive N creation from ~12 kg N $capita^{-1}$ yr^{-1} to ~30 kg N $capita^{-1}$ yr^{-1} (Galloway et al., 2008, 2014). Two principal human activities that cause creation of reactive N are food and energy production (Galloway et al., 2004). Regarding food production, N availability is a limiting factor for biomass production in terrestrial ecosystems (Vitousek et al., 1997). Fertilizer and manure are therefore used in agriculture to increase the amount of N that is available in the soil and can be used by crops for increased productivity (Bobbink et al., 2010; Vitousek et al., 1997). This causes NH_3 emissions (Dentener et al., 2006) and nitrate leaching into groundwater (Vitousek et al., 1997). As for energy production, NO_x is emitted during combustion of fossil fuels. New reactive N is created when atmospheric N_2 is oxidized during this process, sequestered reactive N is released when oxidation of organic N present in the fuel takes place (Galloway et al., 2004). The share of food and energy production in losses of reactive N to the environment is presented in Figure 2-6 for different regions in the world in 2008 (Galloway et al., 2014).

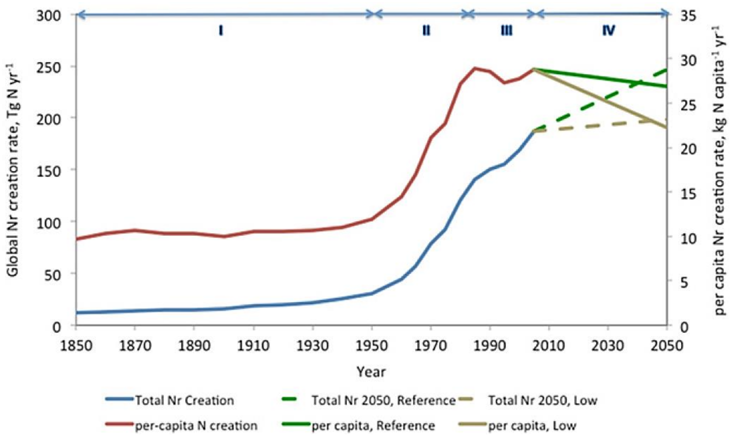


Figure 2-5: Total (left y-axis) and per-capita (right y-axis) global anthropogenic creation of reactive N (Nr) over 200 years (Galloway et al., 2014)**.**

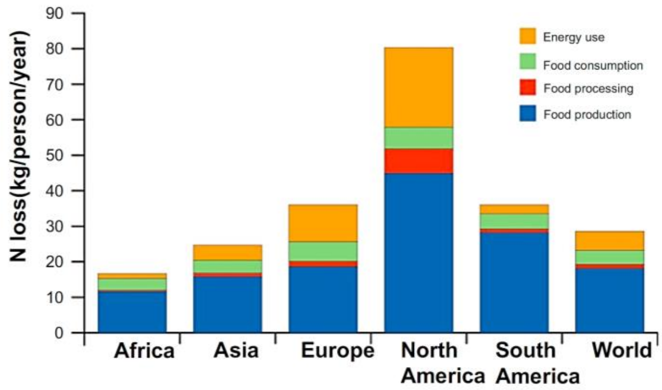


Figure 2-6: Average N losses to the environment per inhabitant in 2008 for different regions in the world (Galloway et al., 2014)**.**

The food and energy producing activities lead to significant changes in the N cycles, causing various environmental impacts:

- Atmospheric concentrations of nitrous oxide (N_2O), a greenhouse gas from fossil fuel combustion and fertilizer use (Vitousek et al., 1997), are increasing. N_2O has a global warming potential (GWP) of 298 times greater than CO_2 (IPCC, 2007b).
- Nitric oxide (NO) is emitted during fossil fuel combustion, and is highly reactive in the atmosphere. Oxidation of NO gives nitric acid, a principal component of acid rain (Vitousek et al., 1997). Since reactive N is then deposited to the Earth's surface (Bobbink et al., 2010), these effects should be evaluated at local or regional scale (Vitousek et al., 1997).
- N availability is a limiting factor to plant growth. If these limitations are relieved by increased deposition of N, biomass production increases. However, biological diversity decreases since plants that are adapted to efficient N use are lost, as well as the species that depend on these plants. In the long run, N saturation is likely to occur. Carbon is no longer stored and N losses to groundwater and the atmosphere will take place in these systems (Vitousek et al., 1997).

Bobbink (2010) showed that N accumulation is the main driver of changes to species composition across different ecosystems. European habitats that are most vulnerable to N deposition are grassland, heathland and forests (Bobbink et al., 2010; Dise et al., 2011). Forests are likely to efficiently capture pollutants containing reactive N compounds and are therefore at risk from N deposition impacts leading to acidification. Excess N initially increases the herbaceous cover with nitrophilic species, however the species richness decreases since N efficient species are lost, eventually leading to biodiversity loss (Bobbink et al., 2010). Heaths are converted into grassland in high N deposition regions (Dise et al., 2011). For grasslands the relationship between increased N deposition and species richness was found to be significantly negative, mainly as a consequence of reduced richness of forbs (Bobbink et al., 2010; Stevens et al., 2009, 2010). Figure 2-7 displays the relationship between N deposition and richness in (a) forbs (i.e. herbaceous flowering plants), (b) grasses, and (c) bryophytes (i.e. non-vascular plants such as mosses) in grasslands in the Atlantic Biogeographic region of Europe (Stevens et al., 2010).

Habitats can be impacted by N deposition through direct toxicity, eutrophication, acidification, and increased sensitivity to secondary stress (Dise et al., 2011). The sensitivity to these impacts differs per habitat type. In Europe, habitat types have been classified based on their vegetation characteristics (European Commission, 1992). For each of these habitat types, a critical deposition load (CDL) is determined (Van Dobben, Bobbink, Bal, & Van Hinsberg, 2012). The CDL

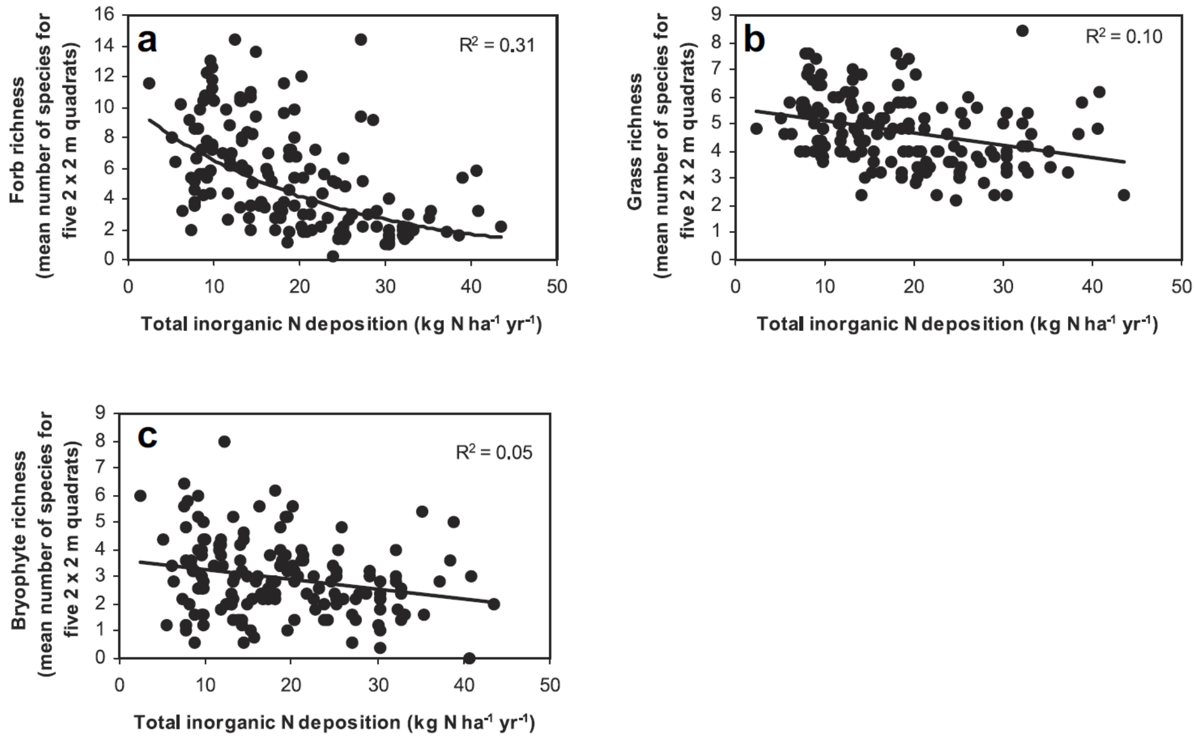


Figure 2-7: Relationships between N deposition and species richness of (a) forbs, (b) grasses, and (c) bryophytes in grasslands in the Atlantic Biogeographic region of Europe (Stevens et al., 2010).

reflects 'the limit above which there is a risk that the quality of the habitat will significantly be affected by the acidifying and/or eutrophicating influence of atmospheric nitrogen deposition' (Van Dobben et al., 2012) in mole and kg N ha^{-1} yr^{-1}. Habitat types with a CDL < 1400 mole N ha^{-1} yr^{-1} are defined as very sensitive, sensitive habitat types typically have a CDL between 1400 and 2400 mole N ha^{-1} yr^{-1} and the habitat type is defined as less or not sensitive to N deposition when the CDL > 2400 mole N ha^{-1} yr^{-1} (Van Dobben et al., 2012).

2.4. Legislation

2.4.1. BIODIVERSITY AND NATURA 2000

At the level of the European Union (EU) a Biodiversity Strategy has been developed. The goal of this strategy is "Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss" (European Commission, 2011). More specific targets and actions can be found in the Habitats and Birds Directives. Both directives aim to maintain or restore a Favourable Conservation Status (FCS) for the flora and fauna in the EU (European Commission, 1992, 2009). Criteria for FCS are specified as follows:

> FCS of a habitat: *(1) its natural range and areas it covers within that range are stable or increasing, (2) the specific structure and functions that are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future and (3) the conservation status of its typical species is favourable.* (Article 1(e), (European Commission, 1992))

> FCS of a species: *(1) population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, (2) the natural range of the species is neither being reduced nor likely to be reduced for the foreseeable future and (3) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.* (Article 1(i), (European Commission, 1992))

Natura 2000 is a European network of protected areas that conserve important flora and fauna. The aim is to prevent further loss of biodiversity in these areas. The network was set to be largely completed by 2012. The Netherlands has currently registered 165 areas (European Commisson, 2016; Ministry of Economic Affairs, 2016b). For the Netherlands, all information concerning Natura 2000 areas can be found online (Ministry of Economic Affairs, 2015c). The Natura 2000 network is part of the national ecological network (*Ecologische Hoofdstructuur, EHS*), aiming at connecting all national natural reserves (Rijksoverheid, 2016).

2.4.2. PROGRAMMATIC APPROACH TO NITROGEN

The Nature Conservancy Act (Dutch Government, 1998) requires that all forms and levels of N deposition are reported. Article 19kh, paragraph 7 (a. 1º.), mentions the existence of an N deposition limit for Natura 2000 sites above which a permit is required to allow extra N emissions. This limit is further specified in the decree on the Programmatic Approach to Nitrogen (PAS) (Dutch Government, 2015). Article 2, paragraph 1 of the Nature Conservancy Act defines the general limit per emitter as 1 mole N ha^{-1} yr^{-1}. Article 2, paragraph 3 however indicates that this limit is lowered to 0.05 mole N ha^{-1} yr^{-1} for Natura 2000 sites that have at least 95% of the still available space for additional N deposition already covered by reportings submitted to PAS. The sites where this is the case can be found at the website of PAS and are presented in Appendix B (PAS-bureau, 2016). The reasoning behind this lower limit is that extra depositions lower than 1 kg N ha^{-1} yr^{-1} (≈ 70 mole N ha^{-1} yr^{-1}) or under 0.5% of the CDL (Jasper, Mouissie, Tuitert, & Kwadijk, 2010) do not result in significant ecological differences in the quality of a habitat. It was estimated that if separate projects remain below the limit of 0.05 mole N ha^{-1} yr^{-1}, the value of ~70 mole N ha^{-1} yr^{-1} is not likely to be exceeded (Dutch Government, 2015).

To determine whether a permit is required, a calculation tool (AERIUS) has been developed that assesses the N depositions at Natura 2000 sites as a consequence of N emissions from a project (Ministry of Economic Affairs, 2015a; Sauter et al., 2016). Appendix A will further elaborate on the characteristics, assumptions and important calculations of this software (Sauter et al., 2016; Van Jaarsveld, 1995), as well as the scientific validation (Sutton et al., 2015). Some definitions of important concepts underlying the calculations by AERIUS are provided here:

Background deposition (BD): 'The total existing deposition as a result of the sum of contributions from all emission sources …' (Bij12, 2015).

Critical deposition load (CDL): '… the limit above which there is a risk that the quality of the habitat will significantly be affected by the acidifying and/or eutrophicating influence of atmospheric nitrogen deposition' (Van Dobben et al., 2012).

N sensitive habitat type: A habitat type is referred to as N sensitive when the CDL is ≤ 2,400 mol N ha^{-1} yr^{-1}. If BD > CDL, an N overload occurs at the habitat type (Bij12, 2015).

N affected species: Species can be affected by N deposition which are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and (1) are directly sensitive to N deposition; and/or (2) are dependent on N sensitive habitat types (Ministry of Economic Affairs, 2015b).

3. METHODOLOGY

3.1. Protocol for biodiversity impact assessment of N deposition

Figure 3-1 presents the 7-step protocol that was developed to assess the impacts on biodiversity as a result of N deposition caused by business activities, and to capitalize biodiversity offsetting. Step 1-4 of the protocol serve to gather the data relevant for answering the research questions. Subsequently, sub-question 1 can be answered in Step 5, sub-question 2 can be answered in Step 6 and sub-question 3 in Step 7 of the protocol.

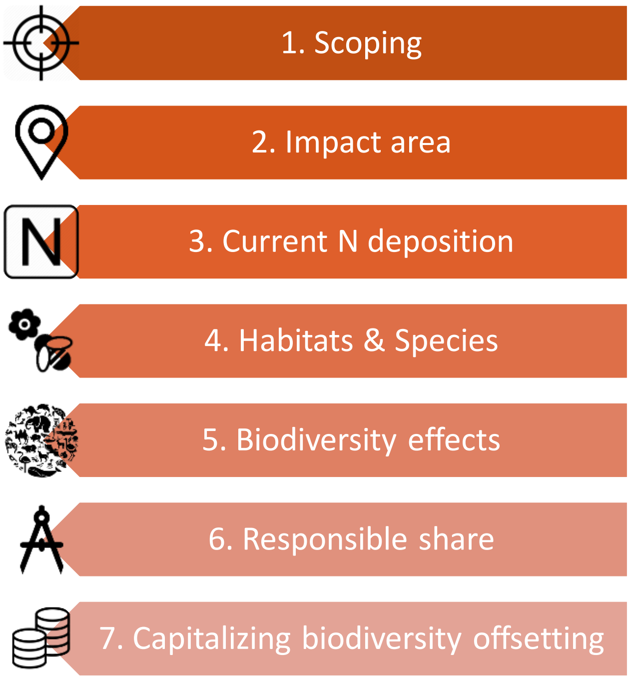


Figure 3-1: Schematic overview of the protocol for biodiversity impact assessment of N deposition

3.1.1. SCOPING

In the scoping step, the system boundaries are defined, both spatially and temporally. Spatially meaning that N emissions can take place throughout the supply chain of the company, relating to their upstream, direct and downstream operations. Temporally refers to emissions that (have) take(n) place in the past, present and future, i.e. during construction, operation and demolition phases. Ideally, and in line with the concept of OPT, the system boundaries should cover the whole supply chain (Eneco, 2014). This includes the construction phase (could involve emissions from the past); operational phase; demolition phase (involves potential future emissions); transport; maintenance, and; sourcing of materials and fuels. However, in this study it was decided to only include the operational phase of the power plants, i.e. electricity and heat production. The reasons for this are 1) data availability is large, the relevant emissions have to be presented annually in the form of an environmental report (Eneco, 2015); 2) this allows for annual impact assessments and monitoring if progress is made; 3) Eneco has direct operational control over these activities; 4) the impacts of N emissions are cumulative and of a very local nature, meaning that more research is necessary to model the stand-alone effects from emissions throughout the chain, e.g. sourcing of the fuel, transport or maintenance emissions.

For the phases that are considered, this step should at least provide the outputs that are listed below. These are input for Step 2. As stated before, companies have to provide this data on a yearly basis in their environmental reports.

- The emissions that are taken into account. Depending on the process characteristics this can be NO_x and / or NH_3;
- The year in which the emissions have taken place;
- The sector that is causing the emissions (e.g. Agriculture, Energy, Shipping);

- The spatial coordinates (x,y) of the emission sources (e.g. the chimney);
- The height of the emission sources in m;
- The heat content of the emissions in MW;
- The emission load in kg/year for NO_x, NH_3 and PM_{10}.

3.1.2. IMPACT AREA

Assumption 1: The impact of N deposition is only reviewed for Natura 2000 sites.

Assumption 2: Within the Natura 2000 sites, only the N deposition at N sensitive habitat types is taken into account, i.e. CDL ≤ 2,400 mole N ha^{-1} yr^{-1}.

This step serves to define the area that is affected by N deposition from the company's operations. Impacts can be local, regional and global, the latter mostly not being applicable to N emissions (Vitousek et al., 1997). To define the impact area of N emissions, a modeling approach is necessary. In The Netherlands AERIUS Calculator is used to calculate N deposition resulting from these emissions (Ministry of Economic Affairs, 2015a). Appendix A will further elaborate on the characteristics of this software. The outputs from Step 1 have to be inserted into the AERIUS Calculator. AERIUS then calculates in which Natura 2000 sites N is deposited, up to 0.05 mole N ha^{-1} yr^{-1}. If multiple projects result in N deposition in a certain area, potential overlaps need to be taken into account as this can lead to cumulative impacts (Galloway et al., 2008).

The following actions were executed in AERIUS for the purposes of this research:

- Direct to: https://calculator.aerius.nl/calculator/.
- The output from Step 1 is the input for AERIUS. This data was extracted from the electronic environmental reports that industrial parties obliged to deliver on a yearly basis (Eneco, 2015).
- Click 'Calculate' to have AERIUS calculate the N deposition at Natura 2000 sites as a result of electricity and heat production in the power plant.
- A PDF and a GML-file can be exported from AERIUS by clicking 'Export' and entering the requested information. The files contain information on:
  - The Natura 2000 sites where N deposition takes place due to electricity and heat production in the specific gas and biomass power plants [Assumption 1];
  - The N deposition up to 0.05 mole N ha^{-1} yr^{-1} due to electricity and heat production in the specific gas and biomass power plants for the N sensitive habitat types per Natura 2000 site [Assumption 2];
  - The surface area of the habitat types where the N deposition exceeds respectively 0.05 and 1 mole ha^{-1} yr^{-1}.

The surface area of the habitat types where the N deposition exceeds 0.05 mole ha^{-1} yr^{-1} is defined as the impact area. The software QGIS (QGIS 2.6.1, 2016) was used to create a deposition map that shows the impact area of each power plant. The AERIUS GML file was opened as a vector layer in QGIS, and a map was created that shows the location of the emission source (power plant chimney) and the N deposition, relative to Natura 2000 sites.

3.1.3. CURRENT N DEPOSITION

This step should determine the current N deposition in the impacted area, i.e. the background deposition. For each Natura 2000 site, the average background deposition is known per habitat type (Ministry of Economic Affairs, 2015b).

The information that should be collected in this step concerns general information which is independent from case-specific emissions. For the purposes of this study, a Source Table was created that also contains the background depositions that should be collected in this step per habitat type per Natura 2000 site. The source table is digitally available in an Excel format (Osseweijer, 2016).

3.1.4. HABITATS AND SPECIES

Assumption 3: Within the N sensitive habitat types, only the species are taken into account which (1) are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and (2) are dependent on N sensitive habitat types.

This step assesses the presence and current state of biodiversity values in the impacted area, i.e. habitats and species.

Habitats

For the N sensitive habitat types that were found to be exposed to N deposition in Step 2 [Assumption 2], the following data is collected to determine their vulnerability:

- Critical Deposition Load (CDL). Habitat types are considered sensitive when the CDL < 2,400 mole N ha^{-1} yr^{-1} (Van Dobben et al., 2012).
- Conservation status as defined by the European Environmental Agency (EEA). This can be either Favourable (FV), Unfavourable-Inadequate (U1) or Unfavourable-Bad (U2) (European Environment Agency, 2014).
- Surface area within the Natura 2000 sites, taking into account the relative coverage (Ministry of Economic Affairs, 2015b).
- Dependent species (see next paragraph).

Species

For each habitat type, it is determined which species are present that could be vulnerable to N deposition. For pragmatic reasons, only species are taken into account that are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009). These species are considered vulnerable when they are dependent upon N sensitive habitat types [Assumption 3]. For each Natura 2000 site, a summary is published with information on these species per habitat type (Ministry of Economic Affairs, 2015b). It is acknowledged that this demarcation might not include all threatened species, but regarding existing databases this is the most pragmatic decision in terms of impact assessment. The following data is collected for these species:

- Conservation status as defined in the species profiles of the Birds and/or Habitats Directive for the Netherlands. This can be either Favourable (F), Moderately Unfavourable (MU) of Very Unfavourable (VU) (Ministry of Economic Affairs, 2015c).
- Conservation status as defined in the IUCN Red List for Europe (IUCN, 2015). The categorization can be found in Figure 3-3 (IUCN, 2010).

The information that should be collected in this step can also be found in the Source Table (Osseweijer, 2016).

3.1.5. BIODIVERSITY EFFECTS

Assumption 4: The general deposition limit above which biodiversity impacts and compensation measures were analysed in this study was set at 1 mole N ha^{-1} yr^{-1}. For the Dutch Natura 2000 sites that already suffer from high N deposition, as shown in in Appendix B, a limit of 0.05 mole N ha^{-1} yr^{-1} was used.

Assumption 5: If the background deposition is lower than the critical deposition load (BD < CDL), it is assumed that the conservation status of habitats and species is not directly negatively impacted by the additional N deposition due to electricity and heat production by Eneco's power plant. If BD > CDL, the possibility exists that the conservation status of habitats and species is negatively impacted by the additional N deposition due to electricity and heat production by Eneco's power plant (Van Dobben et al., 2012).

The results of Step 1-4 were summarized in an output table per power plant. This output table was thoroughly analysed to derive at a cumulative impact value for the biodiversity parameters for which Eneco contributes to a negative impact due to its N deposition, i.e. the number of hectares, Natura 2000 sites, habitat types and present species. Ideally, each Natura 2000 site or even habitat type should have a specific deposition limit, relating to its current state and sensitivity to extra N deposition. Since insufficient information is available for this, it was decided to align the deposition limit with the Dutch legislation on N deposition in relation to permits (see Chapter 2). Appendix B provides an overview of deposition limits per Natura 2000 site according to this legislation (PAS-bureau, 2016). The following requirements were used to determine the impact at the biodiversity parameters:

1) [Assumption 4] only the areas where the general deposition by Eneco exceeds 1 mole N ha^{-1} yr^{-1} are taken into account. For the Dutch Natura 2000 sites that already suffer from high N deposition, as shown in Appendix B, a limit of 0.05 mole N ha^{-1} yr^{-1} was used;

2) [Assumption 5] only the areas where BD > CDL are taken into account. For this, the background deposition is compared with the critical deposition load:

- If BD < CDL, it is assumed that the conservation status of habitats and species is not directly negatively impacted by the additional N deposition due to electricity and heat production by Eneco's power plant.
- If BD > CDL, the possibility exists that the conservation status of habitats and species is negatively impacted by the additional N deposition due to electricity and heat production by Eneco's power plant.

The following filters were applied to the output table (Osseweijer, 2016) to derive at a value for the biodiversity parameters:

Impacted hectares: All unique combinations of Natura 2000 sites and habitat types were filtered, for the areas where requirement 1) and 2) are met. The corresponding surface areas (column H) in ha were summed by using a SUBTOTAL function (Appendix E.I).

Impacted Natura 2000 sites: All areas for which requirement 1) and 2) are met were filtered. From this selection, the unique Natura 2000 sites (column A) were counted by using an array function (Appendix E.I).

Impacted habitat types: All areas for which requirement 1) and 2) are met were filtered. From this selection, the unique habitat types (column C) were counted by using an array function (Appendix E.I).

Impacted species: All areas for which requirement 1) and 2) are met were filtered. From this selection, the unique species (column P) were counted by using an array function (Appendix E.I).

3.1.6. RESPONSIBLE SHARE

Assumption 6: The share of the impact for which independent stakeholders are responsible was calculated by dividing it by the part of the total explained N deposition per Natura 2000 site from emissions caused by Dutch sectors. This approach is taken since a significant part of the total N deposition cannot be attributed to single parties, because it is a result of e.g. natural atmospheric deposition or emissions from abroad.

In the previous step the areas, habitat types and species for which Eneco contributes to potentially (further) degradation were determined. It had to be acknowledged that Eneco is responsible for only a minor share of the background deposition, since this is the cumulation of depositions from numerous sources (e.g. agriculture, traffic, industry, households and atmospheric deposition). Therefore if BD > CDL in an area where Eneco deposited N, Eneco's relative contribution had to be determined. This allowed for putting the actual impact in perspective and possibly coupling avoiding, mitigating or compensating measures to this. The following approach was taken to determine the share of the impact for which Eneco is responsible.

Since eventually the negative impact has to be avoided, mitigated or compensated, the methodology should allow for assigning responsible parties and their corresponding share in the impact. Therefore, the share of the impact for which independent stakeholders are responsible was calculated by dividing their deposition by the part of the total explained N deposition per Natura 2000 site from emissions caused by Dutch sectors. This approach was taken since a significant part of the total N deposition cannot be attributed to single parties, because it is a result of e.g. natural atmospheric deposition or emissions from abroad. The emissions from Dutch sectors could be explained with the highest level of certainty [Assumption 6]. The other way around, Dutch companies also cause biodiversity impacts at foreign sites. The contribution of Dutch sectors to the total background N deposition per Natura 2000 site was included in the Source Table (Osseweijer, 2016). 'Energy' is assessed as a specific sector within the overarching sector 'Industry' and includes emissions related to electricity production (Megens, 2016). This also includes the emissions for which Eneco is responsible.

$$Responsible\ share\ Eneco_i\ [\%] = \frac{N\ deposition\ Eneco_i\ [mole\ N\ ha^{-1}yr^{-1}]}{N\ deposition\ Dutch\ sectors_i\ [mole\ N\ ha^{-1}yr^{-1}]}$$

It is important to take into account to what extent the BD exceeds the CDL, since this determines the magnitude of the impact. E.g. if the BD is 1.5 times higher than the CDL, the local boundary is in fact exceeded 1.5 times, so one-on-one compensation would not be sufficient. Therefore, it was determined what the relative exceedance of the CDL is in each habitat type to define a compensation factor:

$$Compensation\ factor_i = \frac{BD_i\ [mole\ N\ ha^{-1}yr^{-1}]}{CDL_i\ [mole\ N\ ha^{-1}yr^{-1}]}$$

As a last step, the area for Eneco to compensate was calculated by multiplying per habitat type the share for which Eneco is responsible, the compensation factor and the affected surface area from the output table. The final value represents the sum of all small contributions to degradation of the Natura 2000 sites where N deposition by the company exceeds 1 mole N ha^{-1} yr^{-1}, or 0.05 mole N ha^{-1} yr^{-1} for the sites in Appendix B, and BD > CDL:

$$Area\ to\ compensate[ha] = \sum_{i=1}^{n} Responsible\ share\ Eneco_i * Compensation\ factor_i * Affected\ surface\ area_i\ [ha]$$

i = all habitat types (i_1, i_2 … n) situated in Natura 2000 sites where 1) deposition Eneco > 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated Natura 2000 sites in Appendix B, and 2) BD > CDL.

3.1.7. CAPITALIZATION OF BIODIVERSITY OFFSETTING

Assumption 7: This study only looks into ways to offset the negative impacts of N deposition on biodiversity, because: 1) compensation measures should only be taken after the company has tried to minimize its impacts, according to the mitigation hierarchy presented in Figure 1-4 (De Bie & Van Schaick, 2011), 2) avoidance and mitigation of (N) emissions is already far developed in the electricity-supply sector, it can therefore be assumed that no large additional efficiency measures will occur in the industry sectors that result in lower emissions (IPCC, 2007a), and 3) Eneco's newest power plants, i.e. Enecogen and Bio Golden Raand, were recently built according to the latest technologies (respectively 2012 and 2014), it can therefore be assumed that most technological mitigation measures that are available to date have already been taken.

Mitigation hierarchy

The impact of the N deposition by Eneco's electricity and heat power plants is now known in terms of the surface area where Eneco should compensate for the affected habitat types and species. The next step was to determine what measures can be implemented to achieve this. The mitigation hierarchy in Chapter 2 shows that compensation or offsetting measures are only taken after N emissions are sufficiently avoided and mitigated.

Avoidance and mitigation of N emissions would directly lead to a lower amount of impacted hectares, offsetting would imply restoring or conserving the remaining impacted hectares. Since avoidance and mitigation of (N) emissions is already far developed in the electricity-supply sector, e.g. by improving efficiency, applying DeNOx filters or choosing a location that is less N sensitive, it can be assumed that no large additional efficiency measures will occur in the industry sectors (IPCC, 2007a). Specifically for the cases of Enecogen and Bio Golden Raand (see the next section) it can also be assumed that most technological mitigation measures that are available to date have already been taken, since these power plants were recently built according to the latest technologies (respectively 2012 and 2014). Therefore, this study has looked into ways to offset the negative impacts of N deposition on biodiversity [Assumption 7]. No suitable scientifically validated method for this was yet existent.

It needs to be stated that direct biodiversity offsetting in terms of habitats and species is practically impossible. Ideally, offsetting should be done exactly for what has been degraded as a result of the business's activities. In practice however this concerns many small habitat types, and every type of nature has a different value; different habitats, species and ecosystem services that depend upon it. Furthermore, the local nature of N deposition effects would require offsetting to take place at a local level, which in practice is very complex and not desirable due to among others occupation of land for other purposes (Morris, Alonso, Jefferson, & Kirby, 2006). Instead of offsetting, it could therefore be an option to invest more in additional avoidance or mitigation of the effects of N deposition. Five types of measures were identified to reduce the negative biodiversity impacts from N deposition, in a random order:

- Contribution to additional management measures of affected Natura 2000 sites.
- Contribution to additional nature conservation measures that minimize N effects at the affected area, albeit not directly related to the company's N deposition.
- Contribution to N reducing measures in affected Natura 2000 sites.
- Contribution to technological developments to decrease overall N emissions from multiple sectors.
- One-on-one compensation of the impacted area, i.e. land of similar quality and surface area. This is the only actual offsetting measure.

Ideally, the magnitude of the measures should allow to be expressed in one common unit. Monetarization was found to be the best option since this allows for comparison with a large range of parameters (Spurgeon, 2014). Referring to what was said earlier in relation to the value of nature, it would not be correct to express the impact on biodiversity (i.e. habitats and species) in euros. Therefore, the approach of this study was to capitalize biodiversity offsetting to calculate the annual budget that should be allocated to these measures.

Capitalization method

First of all, it is important to state that the method that was used to capitalize biodiversity offsetting does not require implementation of the offsetting measures that determine the cost. Its purpose was to define a budget that should be allocated in a cost-effective way to one or more of the measures that were mentioned earlier.

Biodiversity offsetting of an impacted area is possible by constructing this type of land elsewhere (Morris et al., 2006). It is proposed to use the costs of constructing new nature to determine the biodiversity offsetting costs. There are two main cost components, i.e. purchase of the land and the costs that are associated to the construction activities (Schouten, Leneman, Michels, & Verburg, 2012). Costs for purchasing land for nature purposes differ per province of the Netherlands, the prices are expressed per hectare and are derived from Schouten et al. (2012) (see Appendix C.II). Differences in nature construction costs exist per region and per nature type, due to varying intensities of construction activities, e.g. soil removal, water works, sowing seeds and planting of saplings (Verburg, Puister, Michels, & Hennen, 2016). These costs are expressed per hectare for developing a specific habitat type from prior agricultural land (Schouten et al., 2012). DLG (2009) has developed standardized costs for construction of new nature per nature type for the Dutch ecological network (DLG, 2009). Appendices C.I-C.III provide an overview of the construction costs per nature type, as well as guidance on how these nature types relate to the habitat types in Natura 2000 sites (Portaal Natuur en Landschap, 2014, 2015; Staatsbosbeheer, Natuurmonumenten, De Landschappen, Unie van Bosgroepen, & Federatie Particulier Grondbezit, 2008). The following formula was used to calculate the biodiversity offsetting costs of N deposition per year, distributed over many different Natura 2000 sites and habitat types:

$$Biodiversity\ offsetting\ costs\ of\ N\ deposition\ [€\ yr^{-1}] = \sum_{i=1}^{n} Area\ to\ compensate\ _i[ha] * \quad (r * Land\ price_i[€\ ha^{-1}] + \quad \alpha * Nature\ construction\ cost_i\ [€\ ha^{-1}])$$

For which:

$Area\ to\ compensate_i[ha] = Responsible\ share\ Eneco_i * Compensation\ factor_i * Affected\ surface\ area_i\ [ha]$, calculated in the previous step.

$\alpha\ (annuity\ factor) = \frac{1}{1-(1+r)^{-L}} = 0.051$, providing the annual capital and depreciation cost factor of the construction of nature. For purchased land no depreciation takes place, since land does not wear (Bommel, Boone, Oltmer, & Wijk, 2004). The annual capital cost factor would therefore equal the discount rate (i.e. 3%).

$r\ (discount\ rate) = 3\%$, this was the discount rate for the Dutch economy in 2015 (CPB, 2015). This value is determined on a yearly basis, based on political decisions and the economic situation.

$L\ (lifetime\ of\ constructed\ nature) = 30\ years$, which is the average lifetime after which constructed nature has to be replaced (Schouten et al., 2012).

i = all habitat types (i_1, i_2 … n) situated in Natura 2000 sites where 1) deposition Eneco > 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated Natura 2000 sites, and 2) BD > CDL.

3.2. Data Collection

3.2.1. POWER PLANTS (CASE STUDIES)

The protocol was applied to the assets of Eneco that cause N deposition at Natura 2000 sites as a result of electricity and/or heat production. Figure 3-2 and Table 3-1 provide an overview of all electricity producing assets owned by Eneco in the Netherlands, relative to Natura 2000 sites. Only the gas/biomass power plants (■) have N emissions associated to their business activities. These four power plants (Enecogen, Lage Weide, Merwedekanaal and Bio Golden Raand) were therefore analysed according to the protocol, to assess the impact on biodiversity in Natura 2000 sites as a result of their N deposition due to electricity and/or heat production. Both Lage Weide and Merwedekanaal are connected to the district heating network.

Site visits to Lage Weide and Merwedekanaal (Utrecht) and Bio Golden Raand (Farmsum) were made to understand the specifics of the plants and to inform the directors, environmental experts and permit managers on the objectives of this research. All site-specific information that was used in the study was gathered from the environmental reports that each industrial party in the Netherlands has to submit on a yearly basis (Eneco, 2015).

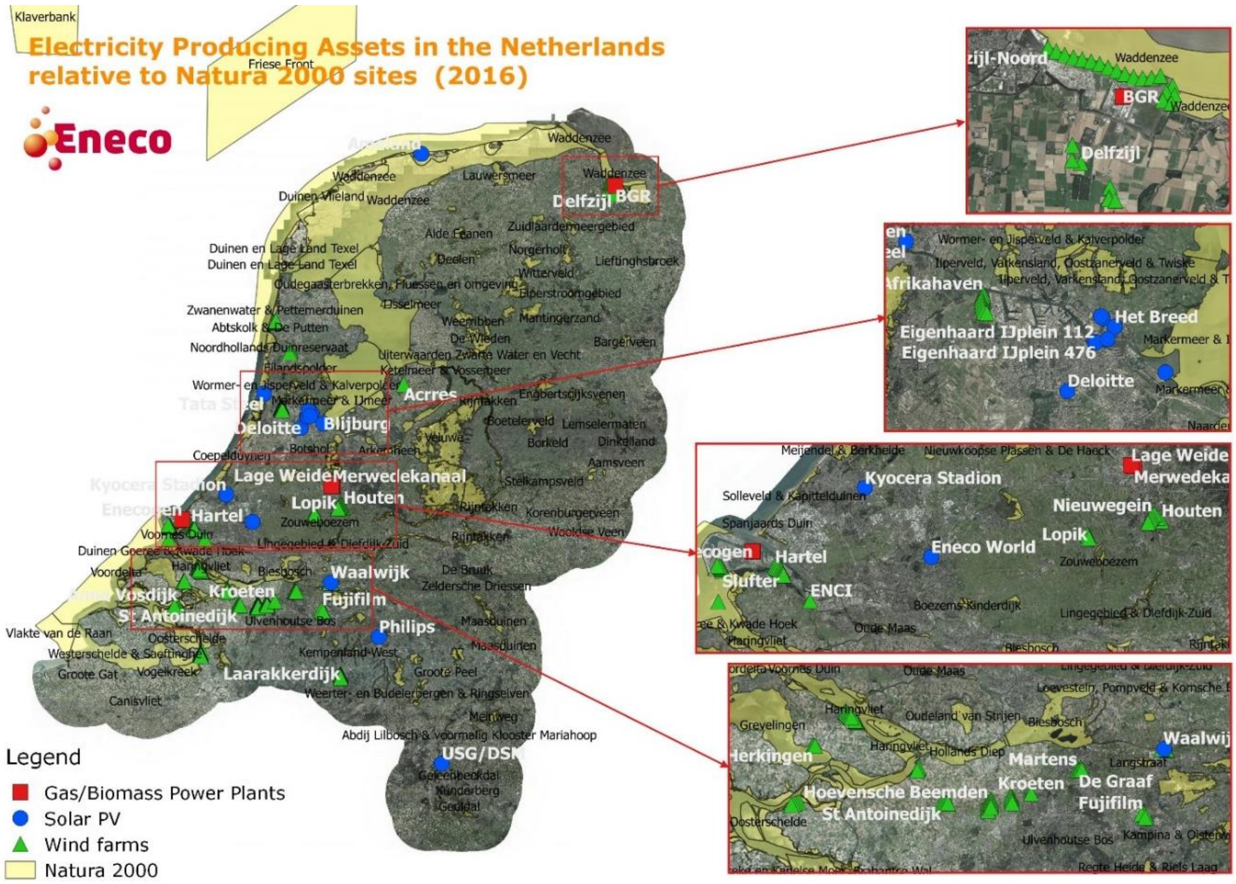


Figure 3-2: Electricity producing assets owned by Eneco in the Netherlands, relative to Natura 2000 sites.

Table 3-1: Characteristics of the power plants for which the N deposition impact was assessed in the case studies (Eneco, 2016).

Power Plant	Type	Fuel	Installed Capacity
Enecogen	Thermal, CCGT	Conventional gas	Electrical: 870 MW
Lage Weide	Thermal, CCGT	Conventional gas	Electrical: 248 MW Thermal: 180 MW
Merwedekanaal	Thermal, CCGT	Conventional gas	Electrical: 225 MW Thermal: 180 MW
Bio Golden Raand	Fluidized-bed boiler	Renewable, biomass	Electrical: 49.9 MW Steam: tbd end of 2016

3.2.2. SOURCE TABLE

As already referred to in the protocol, general data on Natura 2000 sites, habitat types and species was collected into one database, providing the background data that form the basis for all case-specific calculations. The source table can be accessed digitally in Excel (Osseweijer, 2016) and is built from the following parameters:

Parameter	Explanation
[SITECODE_NL]	The sitecode that refers to the Natura 2000 site according to the Dutch classification system (Ministry of Economic Affairs, 2016b).
[SITECODE_EU]	The sitecode that refers to the Natura 2000 site according to the European classification system (European Environment Agency, 2016a).
[Habitat Types (HT) – HABITATCODE]	The habitatcodes that refer to the N sensitive habitat types that are present in the Natura 2000 areas [Assumption 2]. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015).
[Habitat Types (HT) – CS]	The conservation status (CS) of the habitat types in the EU Member States as defined in the biogeographical assessments of species and habitats. The overall CS is determined by taking into account various aspects of the habitat type (e.g. range, area, quality, functionality and future prospects) that are judged by ecological experts (European Environment Agency, 2014).
[Background Deposition (BD) – Average N2K-site]	The average N deposition at all relevant habitat types within the Natura 2000 site in mole N ha^{-1} yr^{-1}. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015).
[Background Deposition (BD) – Dutch Sectors]	The average N deposition at all relevant habitat types within the Natura 2000 site in mole N ha^{-1} yr^{-1} that is caused by Dutch sectors. This information was derived from the AERIUS background data on sectoral contributions. For each Natura 2000 site, AERIUS has determined the contribution per sector to the total N deposition. This can be broken down into emissions caused by Dutch sectors, emissions from abroad and a significant share of 'other emissions' (Megens, 2016). This is displayed in Table 3-2.

Table 3-2: Contribution per sector to total N deposition at Natura 2000 site Waddenzee (Megens, 2016).

CONTRIBUTION PER SECTOR (NL) [mole N ha^{-1} yr^{-1}]						OTHER CONTRIBUTIONS [mole N ha^{-1} yr^{-1}]			TOTAL DEPOSITION [mole N ha^{-1} yr^{-1}]
Agri-culture	Indus-try	Ship-ping	Tran-sport	Infra-structure	Other sectors	Add-ition	Emissions from abroad	NH_3 emissions from sea	
229	15	33	19	12	42	32	278	135	794
349						445			

Parameter	Explanation
[Background Deposition (BD) – Average per HT]	The average N deposition per N sensitive habitat type within the Natura 2000 site in mole N ha^{-1} yr^{-1}. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015).
[Background Deposition (BD) – Lower 10%]	The lower 10%-boundary for the N deposition per N sensitive habitat type within the Natura 2000 site in mole N ha^{-1} yr^{-1}. In 90% of the cases the background deposition exceeds this value. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015). (Input for sensitivity analysis)
[Background Deposition (BD) – Upper 90%]	The upper 90%-boundary for the N deposition per N sensitive habitat type within the Natura 2000 site in mole N ha^{-1} yr^{-1}. In 90% of the cases the background deposition is lower than this value. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015). (Input for sensitivity analysis)
[Critical Deposition Load (CDL)]	For each habitat type 'the limit above which there is a risk that the quality of the habitat will significantly be affected by the acidifying and/or eutrophicating influence of atmospheric nitrogen deposition' (Van Dobben et al., 2012) is given in mole N ha^{-1} yr^{-1}.
[Area – Total]	The total surface area of the habitat types in hectares. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015).
*[Area – Total*Coverage]*	The total surface area of the habitat type in hectares multiplied with its coverage. This information was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015).

Parameter	Explanation
[Species – SPECIESCODE]	The speciescode of the home range species occurring per habitat type that (1) are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and (2) are dependent on nitrogen sensitive habitat types (Assumption 3). The specieslist was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015), the corresponding speciescodes were found at the Natura 2000 Reference Portal of the European Environment Agency (2013).
[Species – SPECIESNAME (Scientific)]	The scientific name of the home range species occurring per habitat type that (1) are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and (2) are dependent on nitrogen sensitive habitat types. The specieslist was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015), the corresponding scientific names were found at the Natura 2000 Reference Portal of the European Environment Agency (2013).
[Species – SPECIESNAME (Dutch)]	The Dutch name of the home range species occurring per habitat type that (1) are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009) and (2) are dependent on nitrogen sensitive habitat types. The specieslist was derived from the site summaries that AERIUS (2015) has developed for every Dutch Natura 2000 site (AERIUS, 2015), the corresponding Dutch names can be found in the species profiles for the Netherlands (Ministry of Economic Affairs, 2015c).
[Species – CS NL]	The conservation status of the species in the Netherlands as defined in their specific profile document. The overall CS is determined by taking into account various aspects of the species (e.g. distribution, population, habitat and future prospects) that are judged by ecological experts (Ministry of Economic Affairs, 2015c).
[Species – CS Red List (IUCN)]	The conservation status of the species as marked on the IUCN Red List for Europe. The categorization used by IUCN is displayed in Figure 3-3 (IUCN, 2010).

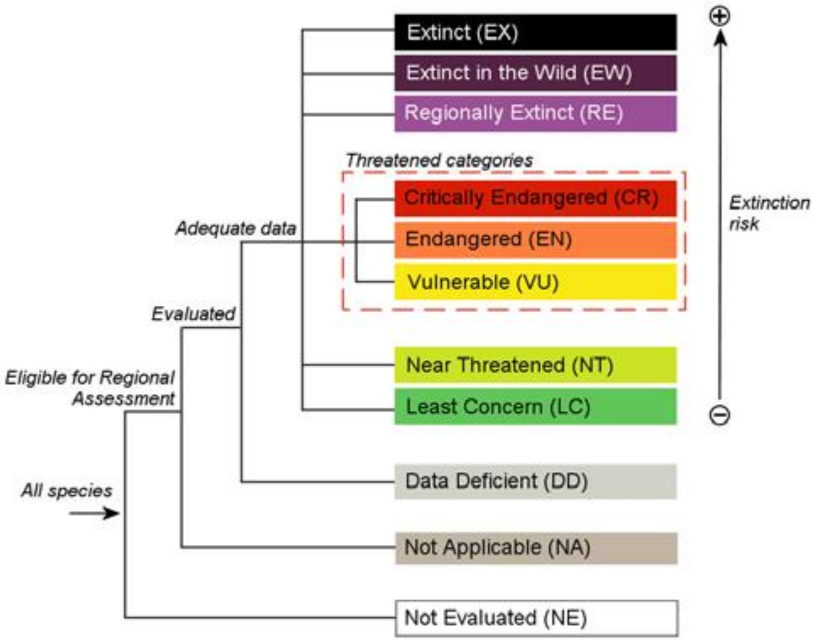


Figure 3-3: Categorization of conservation status of species and habitats according to the IUCN Red List (IUCN, 2010).

3.2.3. APPROACH FOR DEPOSITIONS ABROAD

For the Natura 2000 sites where N deposition by Eneco takes place but which are not situated in the Netherlands (i.e. for this study Germany and Belgium), not all data was readily available. The data gaps and the resulting difference in approach are presented in Table 3-3. With these approaches and assumptions the area that requires compensation could also be determined for the foreign deposition sites.

Table 3-3: Approaches for depositions at foreign sites, if no data was available.

Data gap	Approach
The presence of species dependent on N sensitive habitat types was unknown	Species were not taken into account for the foreign deposition areas
Depositions by the company were only known per Natura 2000 site and not per habitat type	For practical reasons, the deposition value for the Natura 2000 site was assumed to be the same for all habitat types present within the site. The occurring habitat types in foreign sites were extracted from the European Environment Agency (2016).
New habitat types were present for which information on the CDL and the standardized nature costs were unknown	The habitat types for which this was the case and the chosen approach are presented in Appendix C.IV.
The BD was not known per specific habitat type per Natura 2000 site	For *Germany*, the BD was determined from an interactive map (Bundesamt für Umwelt BAFU, 2009) based on the center UTM coordinates[7] of each Natura 2000 site. The BD was given in kg N ha^{-1} yr^{-1} and converted to mole N ha^{-1} yr^{-1} by the following formula: $$BD\,[mole\ N\ ha^{-1}yr^{-1}] = \frac{BD\left[\frac{kg\ N}{ha \cdot yr}\right] * 1 \cdot 10^{3}\left[\frac{g}{kg}\right]}{14.0067\left[\frac{g}{mole}\ N\right]}$$ For practical reasons, this value was then assumed to be the same for all habitat types present within the site. For *Belgium*, the less accurate EMEP model was used, which calculates long-range transboundary air pollution data at a 50x50 km grid[8] (Convention on Long-range Transboundary Air Pollution, 2014). The total oxidized and reduced N depositions were extracted for 2014 in mg N m^{-2} yr^{-1}, both as a semicolon separated file and a graphic map (Figure 3-4). The data was converted to mole N ha^{-1} yr^{-1} by the following formula: $$BD\,[mole\ N\ ha^{-1}yr^{-1}] = \frac{BD\left[\frac{mg\ N}{m^{2} \cdot yr}\right] * 1 \cdot 10^{-3}\left[\frac{g}{mg}\right] * 1 \cdot 10^{4}\left[\frac{m^{2}}{ha}\right]}{14.0067\left[\frac{g}{mole}\ N\right]}$$

[7] The coordinates of the center of the Natura 2000 site were only known in terms of latitude and longitude. For the interactive map they were required to be expressed as UTM coordinates. GPScoordinaten.nl (2016) was used to correctly convert these coordinates.

[8] The EMEP grid system is based on a polar-stereographic projection, see also Figure 3-4. The following calculations were used to convert this into latitude and longitude coordinates that were needed to match the deposition sites (ECE/EB.AIR, 2008; RIVM, 2010):

Latitude: $\varphi = 90 - \frac{360}{\pi} arctan\left(\frac{r}{M}\right)$

Longitude: $\lambda = \lambda_0 + \frac{180}{\pi} arctan\left(\frac{x-xpol}{ypol-y}\right)$

Where:

xpol	= 8	(x coordinate of the North Pole)
ypol	= 110	(y coordinate of the North Pole)
d	= 50 km	(grid length at 60˚N)
ϕ_0	= 60˚N = π/3	(defining latitude)
R	= 6370 km	(radius of the Earth)
M	= $\left(\frac{R}{d}\right) * (1 + \sin(\varphi_0))$	(237.73, number of grid distances between North Pole and equator)
r	= $\sqrt{(x - xpol)^2 + (y - ypol)^2}$	
λ_0	= -32	(32 ˚W, rotation angle, i.e. longitude parallel to the y-axis)

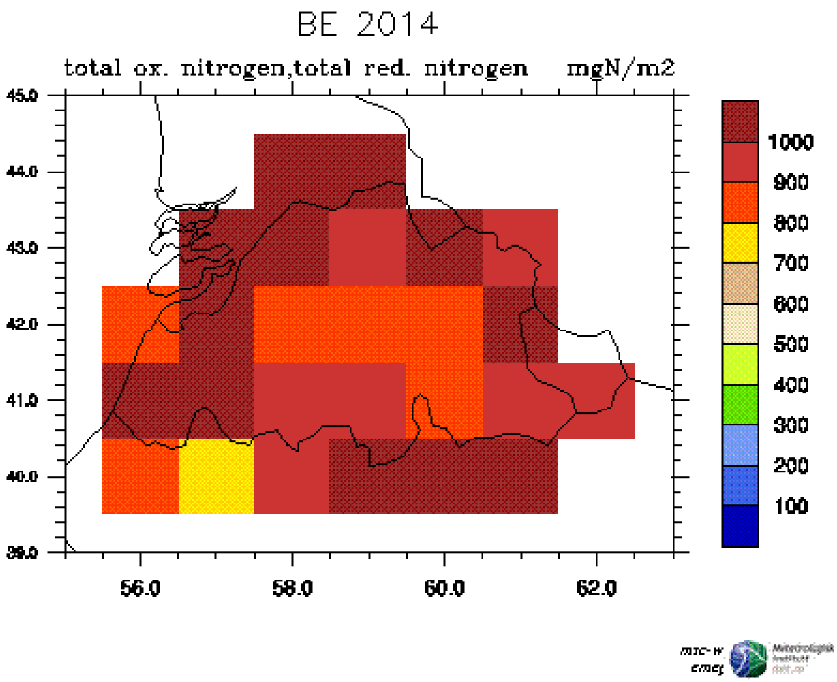


Figure 3-4: Graphic map (50x50km grid) for deposition of oxidized and reduced nitrogen in Belgium for 2014 in mg N m^{-2} yr^{-1} (Convention on Long-range Transboundary Air Pollution, 2014)**.**

Data gap	Approach
	The BD was now known per grid cell, for longitude and latitude coordinates. For each Natura 2000 site, the BD was interpolated based on these coordinates. This is not entirely correct since no linear relationship exists, but was considered to be the best approach until more accurate grid data becomes available. For practical reasons, this BD value was then assumed to be the same for all habitat types present within the Natura 2000 site.
The contribution in N deposition of different sectors to the BD was not known	The share of the deposition by Dutch sectors of the total BD was determined for each Natura 2000 site, and the average sectoral deposition (Megens, 2016) in the Netherlands was calculated to be 55.43% of the total BD. For the Belgian and German Natura 2000 sites the sectoral deposition was now assumed to be 55.43% of the BD.
The legislation on the deposition limit above which approval from the competent authority is required is different in both countries. In Germany, this limit is 7.14 mole N ha^{-1} yr^{-1}. In Belgium, this limit is 3% of the CDL of the N sensitive habitat type (Bij12, 2016).	Both values were considered too high for the purposes of this research, since the goal is to determine the environmental impact and not to determine whether a permit is required. Therefore, the general deposition limit that was used in the Netherlands (i.e. 1 mole N ha^{-1} yr^{-1}) was also used for all German and Belgian sites.

3.3. Sensitivity Analysis

A sensitivity analysis was performed on the quantitative parameters that influence the result. This was done to indicate the sensitivity of the result to changes in these input data. Table 3-4 shows the quantitative parameters that were used in this research, and how they were addressed in the sensitivity analysis. For each of the parameters a low and a high scenario was defined, next to the base scenario that was calculated in the protocol. The range over which was varied is based on the uncertainty of the values. If no data on the uncertainty of a parameter was present, an arbitrary range of +/- 10% was used. Since all parameters influence the final result by multiplication, as can be seen in the formulas in Step 6 and 7, this also is the case for the associated uncertainties. It needs to be mentioned, however, that this is not necessarily a direct relationship because effects are only taken into account if the deposition limit is exceeded [Assumption 4] and BD > CDL [Assumption 5], which is no guarantee when the uncertainty ranges are applied.

Table 3-4: The quantitative parameters that were included in the sensitivity analysis, along with their influence at the result and their uncertainty range.

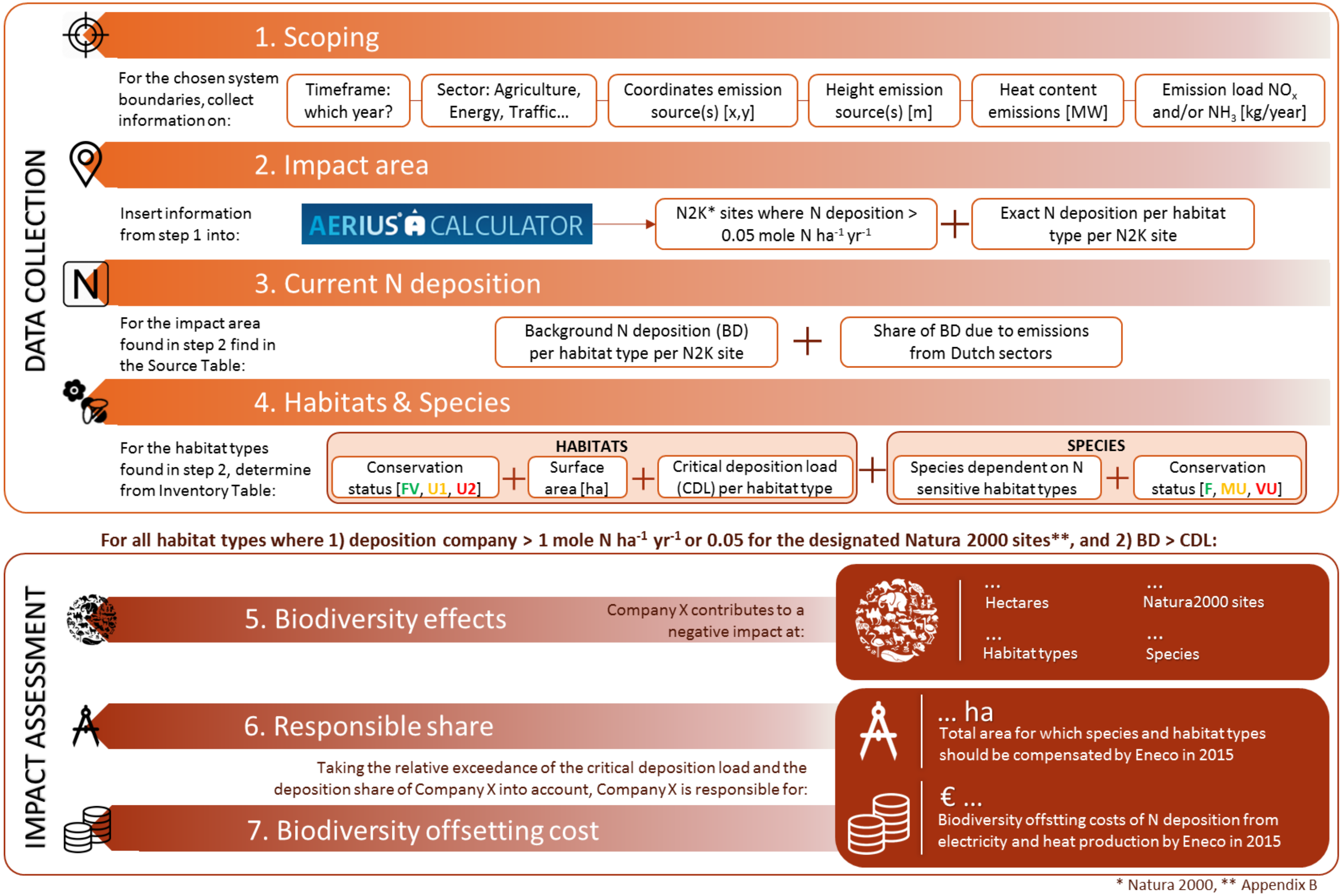
Parameter	Influence at result	Uncertainty range
Deposition by the company at Natura 2000 sites	Depositions should be higher than the deposition limit in order to be included in the calculations. Higher depositions would therefore lead to more situations that are included in the impact assessment and therefore positively influence the result.	Total uncertainty is 30%: +/- 15%, (Ministry of Economic Affairs, 2013) Low scenario: -15% High scenario: +15%
Deposition limit [Assumption 4]	The deposition limit (1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated sites) defines the boundary above which the effect of N deposition is assessed. When the deposition limit is higher, less situations are included in the impact assessment and the result is negatively affected.	Low scenario: 0.05 mole N ha^{-1} yr^{-1} High scenario: 1 mole N ha^{-1} yr^{-1}
CDL	The CDL defines the deposition load above which the impact of extra depositions is assessed. A higher CDL would therefore negatively impact the result, since it becomes less likely that the load is exceeded.	Low scenario: -10% High scenario: +10%
BD [Assumption 5]	The BD defines the deposition that is already present at a site. If BD > CDL, the situation is included in the impact assessment. A higher BD would therefore positively impact the result, since it becomes more likely that the CDL is exceeded. When using the same uncertainty ranges, the effect on the result would be exactly opposite from varying the CDL.	Uncertainty ranges are known for each habitat type within the Dutch Natura 2000 sites. See the Source Table, (Osseweijer, 2016). For foreign Natura 2000 sites, the uncertainty range from AERIUS of 30% is used (Ministry of Economic Affairs, 2013). Low scenario: -15% High scenario: +15%
Deposition by Dutch sectors (share of BD)	The deposition by Dutch sectors (i.e. the explained deposition) was used to determine the company's responsible share. A higher explained deposition would negatively impact the result, since the relative share of the company becomes smaller. Varying this parameter would have the exact opposite effect as varying the deposition by the company, and is therefore not included.	n/a
Surface area habitat types	The surface area of the habitat types determines the amount of land that should be compensated. If more accurate delimitation would measure larger	Low scenario: -10% High scenario: +10%

Parameter	Influence at result	Uncertainty range
	areas, this would positively impact the result, since more hectares require compensation.	
Discount rate	The discount rate (3%) determines the annual costs of an investment. A higher discount rate would increase the annual costs and therefore positively influence the result.	No actual uncertainty range applicable since this value is determined on a yearly basis, based on political decisions and the economic situation. The sensitivity analysis therefore merely shows the fictional sensitivity of the result to this parameter, not necessarily a realistic range. Low scenario: 1% High scenario: 5%
Price land construction	The price of land construction contributes to the biodiversity offsetting cost of N deposition. A higher land price would increase these costs and therefore positively affects the result.	Low scenario: -10% High scenario: +10%

4. RESULTS

4.1. Flowchart protocol

The first result of this study is the protocol that was developed to assess the impacts on biodiversity in Natura 2000 sites as a result of N deposition caused by business activities, as well as the biodiversity offsetting costs associated to this. This methodology is schematically presented here:



4.2. Case studies

The results of the case studies are presented per power plant in the next sections (Case 1-4). Case 1, Lage Weide, is presented stepwise according to the protocol, for the other cases only the final results are given in order to prevent too much repetition.

4.2.1. LAGE WEIDE

1. *Scoping*

The results from the scoping step, i.e. system boundaries; year of interest; type of emissions; coordinates and height of the emission source(s); heat content and the emission load, are presented in Appendix D.I.1.

2. *Impact area*

The N deposition by Lage Weide at habitat types where 1) 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} for the designated Natura 2000 sites is exceeded, and 2) where BD > CDL is presented in Appendix D.II.1. The impact area of Lage Weide is shown in Figure 4-1 for depositions higher than 0.05 mole N ha^{-1} yr^{-1}.

3. *Current N deposition*

The current background deposition rates for the impacted areas were studied. This is presented in Appendix D.II.1.

4. *Habitats & Species*

All N sensitive habitat types were analysed where 1) the N deposition by Lage Weide exceeds 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} for the designated Natura 2000 sites (Appendix B), and 2) where BD > CDL. Subsequently, an analysis was made for the species that are dependent upon these habitat types. This is also summarized in Appendix D.II.1. The table contains information that is relevant to Step 5 and 6 as well.

5. *Biodiversity effects*

Figure 4-2 shows the potential biodiversity impacts to which Lage Weide contributed as a result of its N deposition in 2015, for depositions exceeding 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated Natura 2000 sites (see Appendix B for an overview of the deposition limits), and BD > CDL. For these situations, the amount of hectares affected is displayed along with the number of Natura 2000 sites in which these areas can be found. Furthermore, the number of different N sensitive habitat types that are present in these areas and the number of different Birds and/or Habitats Directive species that are dependent on these habitat types are given.

6. *Responsible share*

The surface area that should be compensated by Eneco for its Lage Weide power plant can be calculated for each habitat type that is presented in Appendix D.II.1. by multiplying the responsible share with compensation factor and the area where the deposition exceeds 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated Natura 2000 sites in Appendix B. Summing these contributions gives a total area of **13 ha** that Eneco should conserve in order to compensate for its biodiversity impacts due to N deposition from Lage Weide in 2015, Figure 4-2. This area is in reality distributed over a large amount of different habitat types, so guidelines for compensation have to be developed. Chapter 5 will briefly touch upon this.

7. *Capitalization of biodiversity offsetting*

The biodiversity offsetting costs are the costs that would be associated to constructing the habitat types that were proposed for compensation in the previous step, elsewhere. These costs were calculated by multiplying the area to compensate with the discounted land price (Appendix C.II) and discounted nature construction costs of each habitat type (Appendix C.III). Summing all shares gives a total biodiversity offsetting cost of **€ 35,952** in 2015, this budget should be deployed to reduce negative impacts of N deposition from Lage Weide, Figure 4-2. This budget should in reality be distributed over a large amount of different habitat types, so guidelines for compensation have to be developed. Chapter 5 will briefly touch upon this.

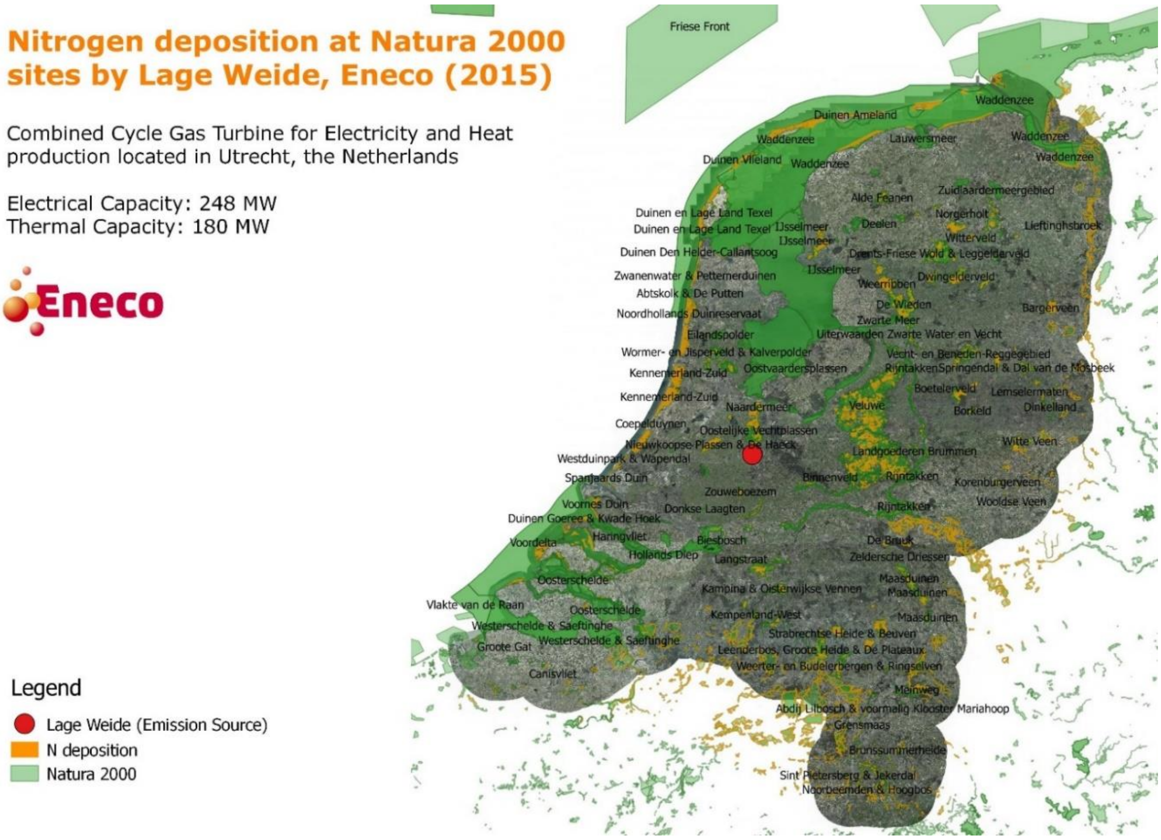


Figure 4-1: N deposition at Natura 2000 sites by Lage Weide in 2015 for concentrations > 0.05 mole N ha^{-1} yr^{-1}.

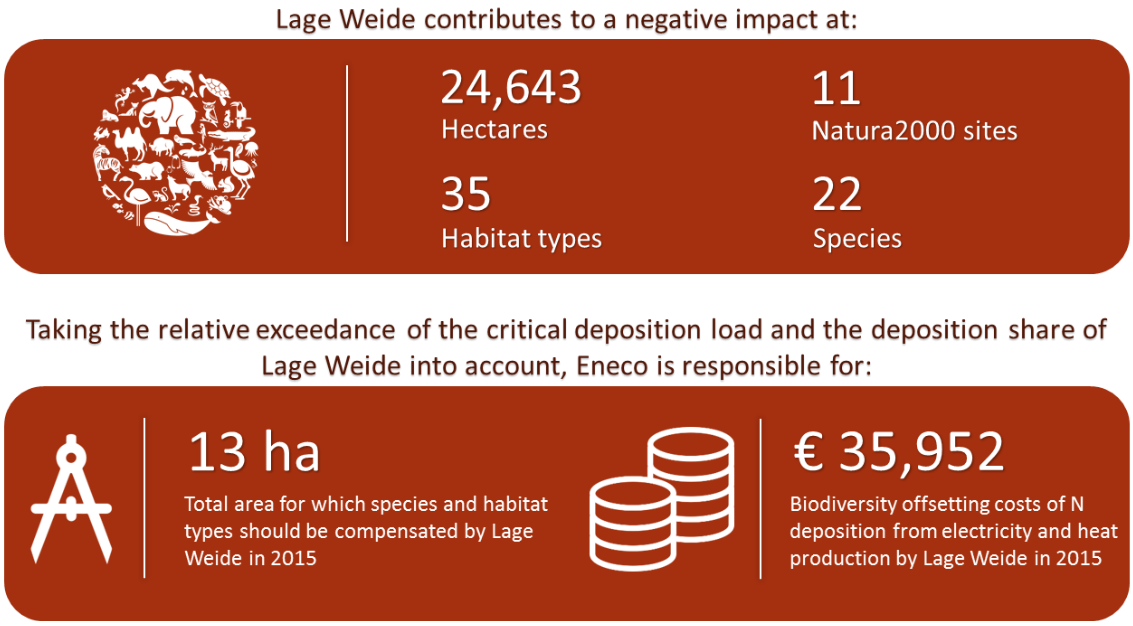


Figure 4-2: Eneco's power plant Lage Weide contributes to a negative impact at the above parameters as a result of its N deposition in areas where this exceeded 1 mole N ha^{-1} yr^{-1} (or 0.05 mole N ha^{-1} yr^{-1} in the designated sites), and BD > CDL. Eneco is responsible for compensation of 13 ha, implying a total biodiversity offsetting cost of N deposition of € 35,952 in 2015.

4.2.2 MERWEDEKANAAL

1. *Scoping* Appendix D.I.2.
2. *Impact area* Appendix D.II.2. and Figure 4-3.
3. *Current N deposition* Appendix D.II.2.
4. *Habitats & Species* Appendix D.II.2.
5. *Biodiversity effects – 7. Capitalization of biodiversity offsetting* Figure 4-4

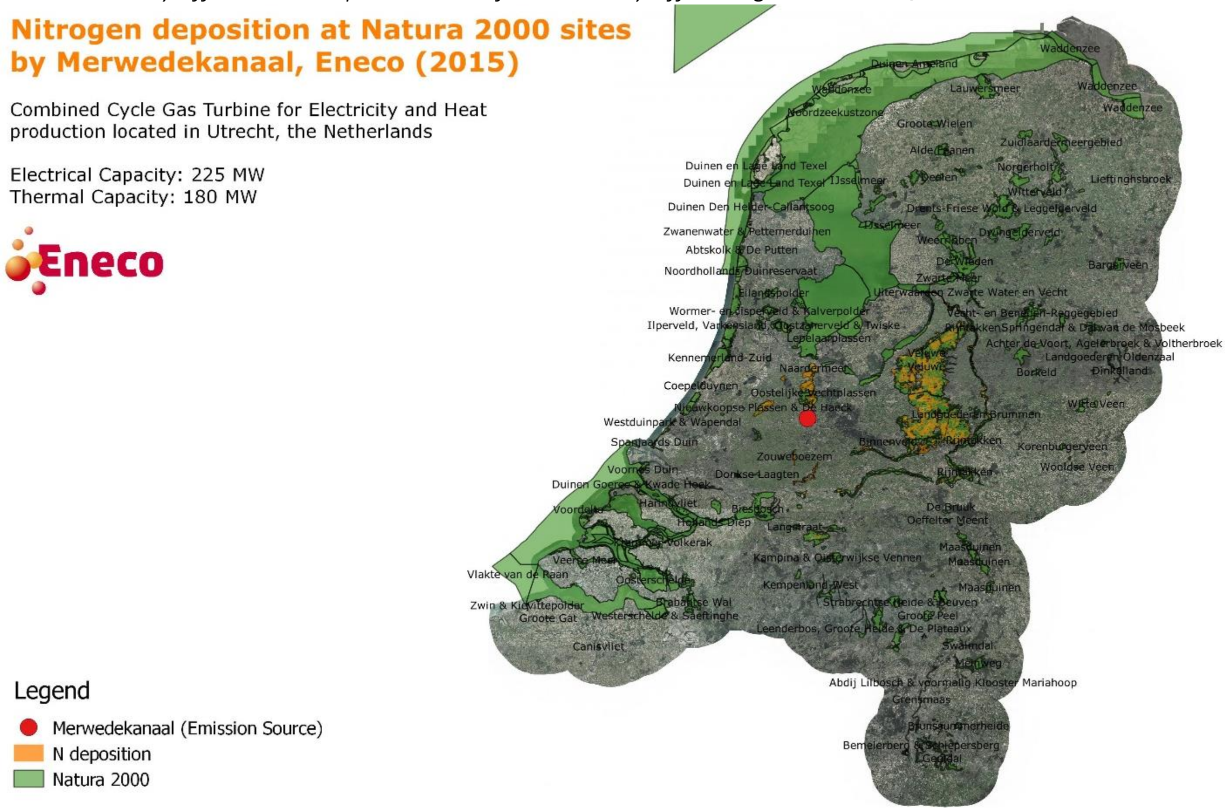


Figure 4-3: N deposition at Natura 2000 sites by Merwedekanaal in 2015 for concentrations > 0.05 mole N ha^{-1} yr^{-1}.

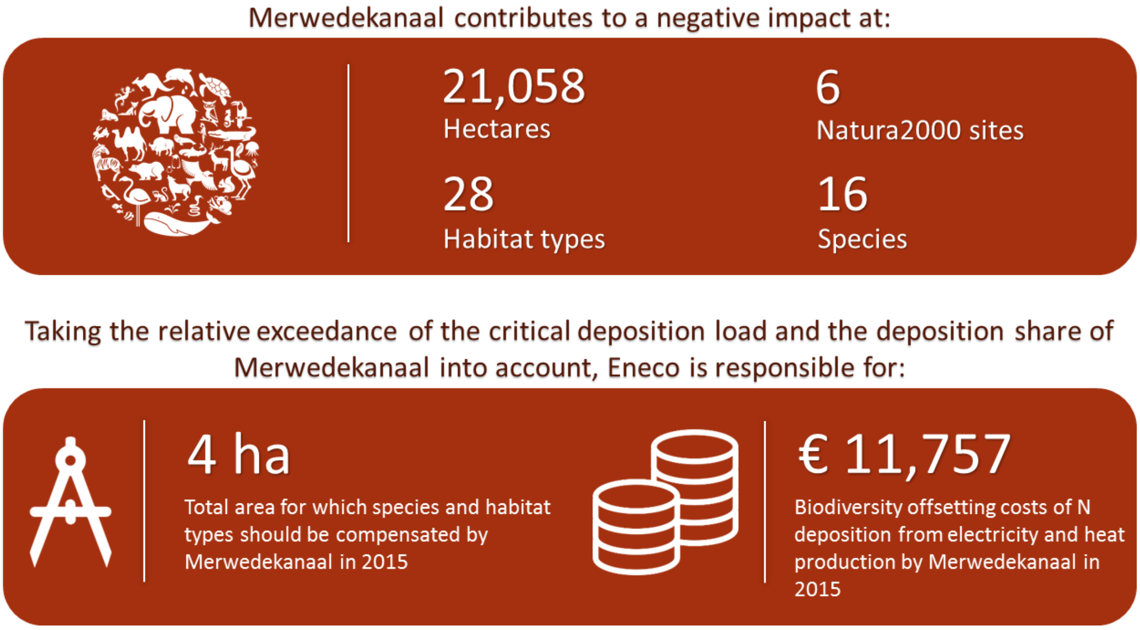


Figure 4-4: Eneco's power plant Merwedekanaal contributes to a negative impact at the above parameters as a result of its N deposition in areas where this exceeded 1 mole N ha^{-1} yr^{-1} (or 0.05 mole N ha^{-1} yr^{-1} in the designated sites), and BD > CDL. Eneco is responsible for compensation of 4 ha, implying a total biodiversity offsetting cost of N deposition of € 11,757 in 2015.

4.2.3 ENECOGEN

1. *Scoping* — Appendix D.I.3.
2. *Impact area* — Appendix D.II.3. and Figure 4-5.
3. *Current N deposition* — Appendix D.II.3.
4. *Habitats & Species* — Appendix D.II.3.
5. *Biodiversity effects – 7. Capitalization of biodiversity offsetting*

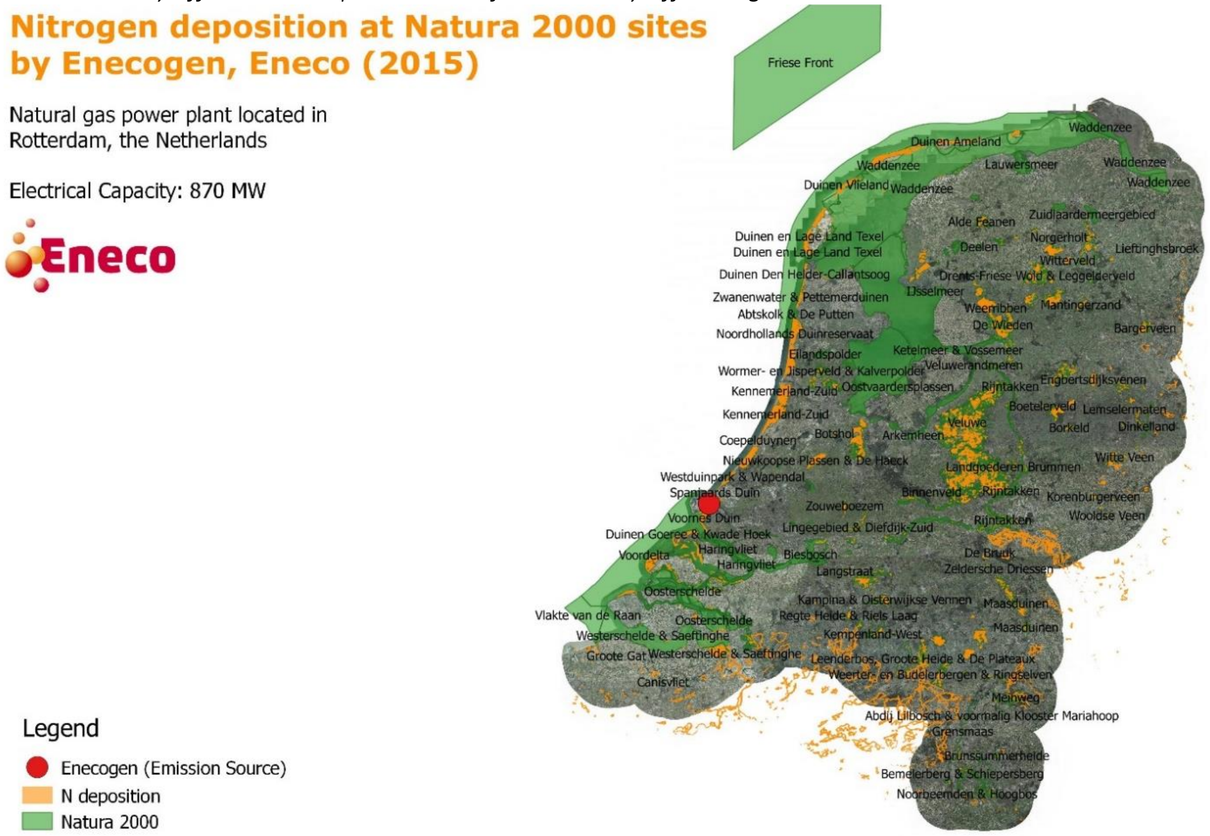


Figure 4-5: N deposition at Natura 2000 sites by Enecogen in 2015 for concentrations > 0.05 mole N ha^{-1} yr^{-1}.

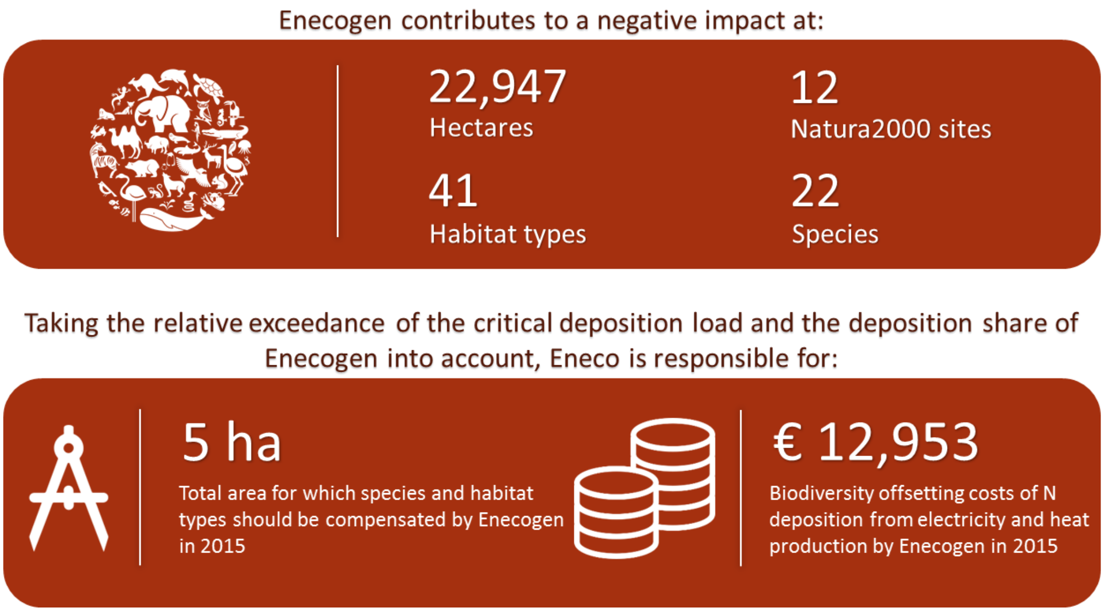


Figure 4-6: Eneco's power plant Enecogen contributes to a negative impact at the above parameters as a result of its N deposition in areas where this exceeded 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated sites, and BD > CDL. Eneco is responsible for compensation of 5 ha, implying a total biodiversity offsetting cost of N deposition of € 12,953 in 2015.

4.2.4 BIO GOLDEN RAAND

1. *Scoping* Appendix D.I.4.
2. *Impact area – 7. Capitalization of biodiversity offsetting*

The total impact area of Bio Golden Raand is shown in Figure 4-7 for depositions higher than 0.05 mole N ha^{-1} yr^{-1}. It was found that in both the Netherlands and Germany in none of the Natura 2000 sites the site-specific limit was exceeded by the emissions of Bio Golden Raand. The contribution to biodiversity impact from N deposition by Bio Golden Raand can be assumed to be negligible and no further compensation is required at this point in time, as displayed on the dashboard in Figure 4-8.

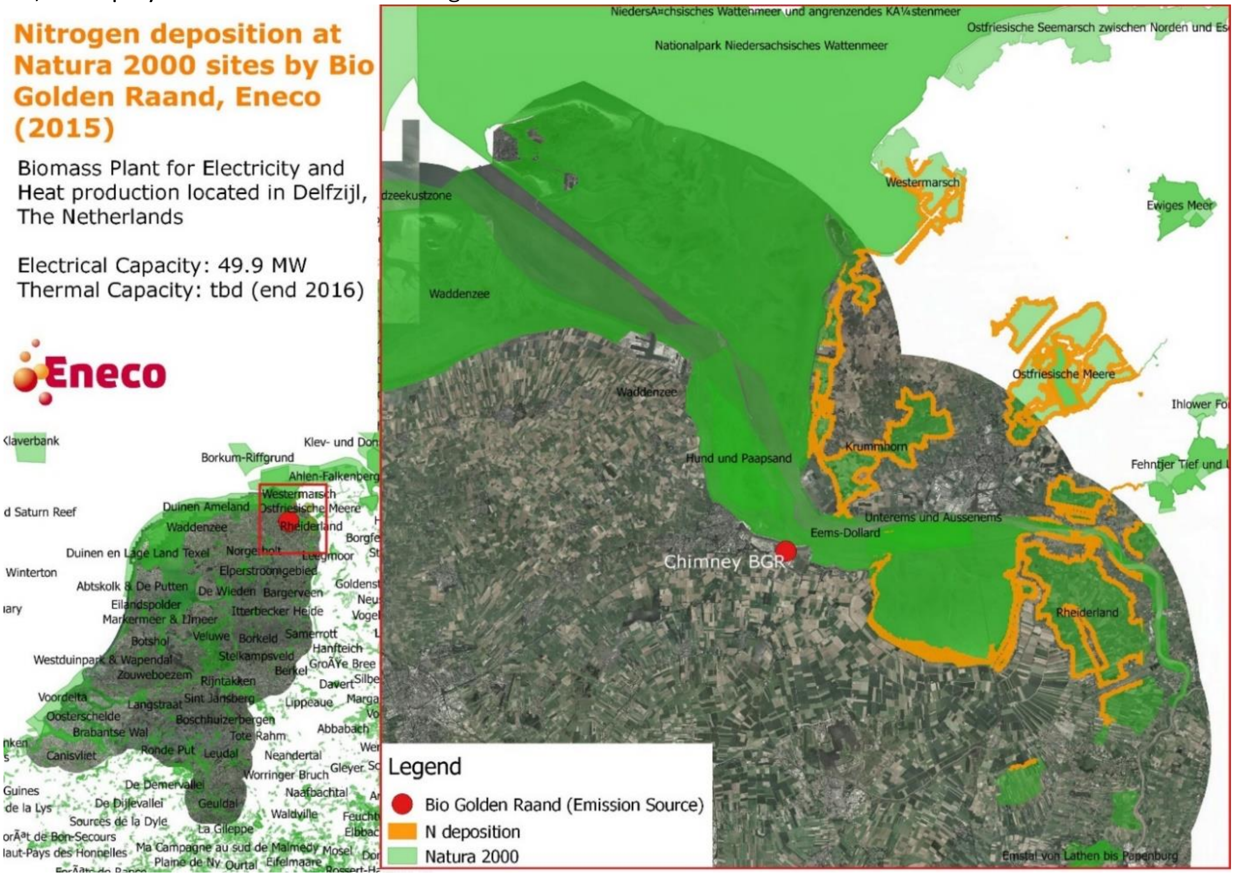


Figure 4-7: N deposition at Natura 2000 sites by Bio Golden Raand in 2015 for concentrations > 0.05 mole N ha^{-1} yr^{-1}.

Bio Golden Raand contributes to a negative impact at:

0 Hectares
0 Natura2000 sites
0 Habitat types
0 Species

Taking the relative exceedance of the critical deposition load and the deposition share of Bio Golden Raand into account, Eneco is responsible for:

0 ha
Total area for which species and habitat types should be compensated by Bio Golden Raand in 2015

€ 0
Biodiversity offsetting costs of N deposition from electricity and heat production by Bio Golden Raand in 2015

Figure 4-8: Eneco's power plant Bio Golden Raand does not significantly contribute to a negative impact at the above parameters as a result of its N deposition. No compensation is required, and the total biodiversity offsetting cost of N deposition were found to be of € 0 in 2015.

4.2.5 OVERALL RESULT

In 2015, the power plants of Lage Weide, Merwedekanaal, Enecogen and Bio Golden Raand have together produced 4,368,693 MWh (4.4 TWh) electricity, causing 764,108 kg NO_x and 2,451 kg NH_3 emissions (Appendix D.I). These N emissions from the production phase caused biodiversity impacts at Natura 2000 sites in the Netherlands, Belgium and Germany, and therefore the following should be compensated by Eneco for 2015. These hectares and costs are distributed over a large amount of different habitat types, and therewith habitats and species in the affected Natura 2000 sites.

Taking the relative exceedance of the critical deposition load and the deposition share of Eneco's power plants in all habitat types into account, in 2015 Eneco was responsible for:

23 ha
Total area for which species and habitat types should be compensated by Eneco in 2015

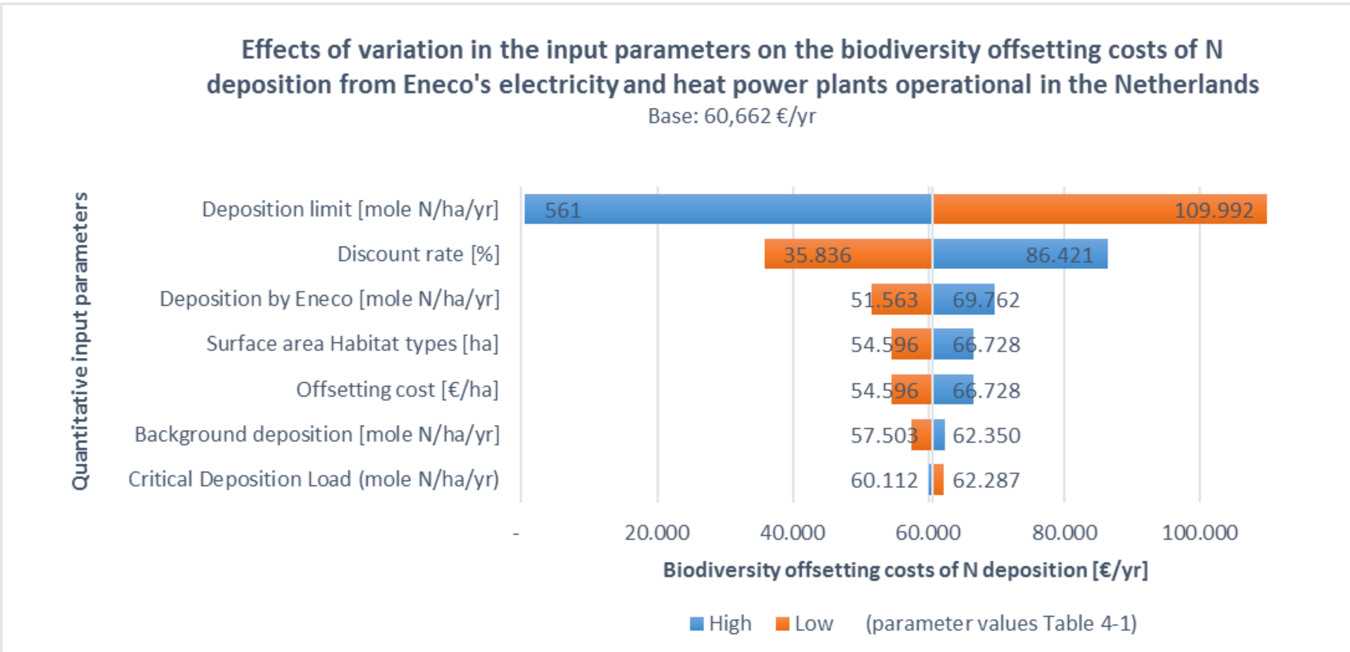
€ 60,662
Biodiversity offsetting costs of N deposition from electricity and heat production by Eneco in 2015

4.3 Sensitivity analysis

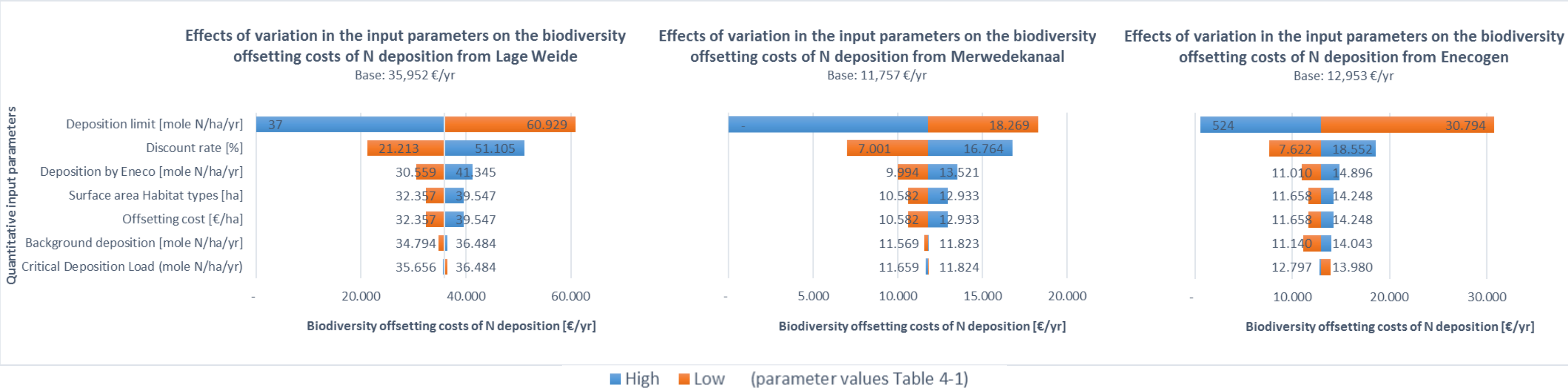
A sensitivity analysis was performed on the quantitative input parameters and assumptions, to assess their individual impact on the biodiversity offsetting costs of N deposition. The range over which each of the parameters was varied is displayed in Table 4-1. Graph 4-1 provides the sensitivity of the biodiversity offsetting costs of N deposition to all parameters for all gas and biomass power plants operated by Eneco in the Netherlands, and Graph 4-2 shows this per power plant. The outcomes for Bio Golden Raand remained zero also in the sensitivity analysis, therefore no graph is included for this plant. In Graph 4-3, for the foreign deposition sites the sensitivity of the biodiversity offsetting costs of N deposition to the assumed deposition limit is presented per power plant. Since the underlying assumptions for the depositions abroad slightly differ and the result for the base scenario was zero, it was decided to present this in a separate graph. Varying the other parameters still gave zero impact at foreign sites. The parameters will be discussed separately in Chapter 5.

Table 4-1: Variation of each of the parameters in the sensitivity analysis.

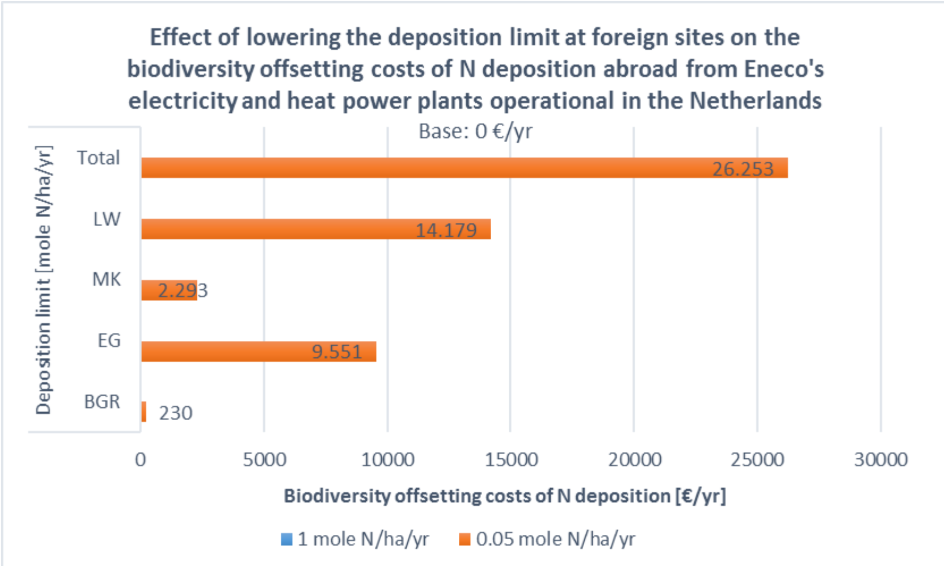
Parameter	Base	High	Low	Impact
Deposition limit [mole N ha^{-1} yr^{-1}]	1 mole N ha^{-1} yr^{-1} in general and 0.05 mole N ha^{-1} yr^{-1} in the designated sites	1 mole N ha^{-1} yr^{-1}	0.05 mole N ha^{-1} yr^{-1}	Negative
Discount rate [%]	3%	5%	1%	Positive
Deposition by Eneco [mole N ha^{-1} yr^{-1}]	Appendix D.II	+15%	-15%	Positive
Surface area habitat types [ha]	Appendix D.II	+10%	-10%	Positive
Offsetting cost [€ ha^{-1}]	See Dashboards	+10%	-10%	Positive
Background deposition [mole N ha^{-1} yr^{-1}]	Appendix D.II	Appendix D.II	Appendix D.II	Positive
Critical deposition load [mole N ha^{-1} yr^{-1}]	Appendix D.II	+10%	-10%	Negative



Graph 4-1: Sensitivity analysis of the impact of the quantitative parameters on the biodiversity offsetting costs of N deposition for Eneco's gas and biomass power plants operational in the Netherlands, presented in a tornado diagram. A wide bar means that the results are very sensitive to the parameter, the colors indicate whether the relationship is positive or negative (orange-blue = positive / blue-orange = negative).



Graph 4-2: Sensitivity analysis of the impact of the quantitative parameters on the biodiversity offsetting costs of N deposition per power plant, presented in a tornado diagram. A wide bar means that the results are very sensitive to the parameter, the colors indicate whether the relationship is positive or negat ive (orange-blue = positive / blue-orange = negative).



Graph 4-3: Sensitivity analysis of the impact of lowering the deposition limit to 0.05 mole N ha^{-1} yr^{-1} for the foreign deposition sites on the biodiversity offsetting costs of N deposition per power plant and in total abroad. LW = Lage Weide, MK = Merwedekanaal, EG = Enecogen, BGR = Bio Golden Raand.

The following is visible from the tornado graphs per parameter, when approached as an increase of the parameter values (high end):

- Deposition limit: Increasing the deposition limit causes significantly lower biodiversity offsetting costs of N deposition
- Discount rate: An increase in the discount rate in the next year clearly increases the biodiversity offsetting costs of N deposition
- Deposition by Eneco: An increase in the deposition by Eneco causes a direct increase in the biodiversity offsetting costs of N deposition
- Surface area habitat types: In case more accurate delimitation of sites causes an increase in the measured surface area of the habitat types, this directly results in higher biodiversity offsetting costs of N deposition
- Nature construction cost: An increase in the costs of construction new nature causes a direct increase in the biodiversity offsetting costs of N deposition
- Background deposition: A higher background deposition slightly increases the biodiversity offsetting costs of N deposition
- Critical deposition load: A higher critical deposition load slightly decreases the biodiversity offsetting costs of N deposition.

5 DISCUSSION AND RECOMMENDATIONS

5.1 Interpretation of the results

5.1.1 CASE STUDIES

For all power plants it can be said that the final outcomes (area to compensate and the biodiversity offsetting costs of N deposition) will return on a yearly basis, assuming constant efficiency and production. A few things can be noticed when comparing the cases.

First of all, the amount of hectares and habitat types at which Lage Weide, Merwedekanaal and Enecogen contribute to a negative impact are relatively similar, respectively around 23,000 ha and 30-40 different habitat types. However, for Lage Weide the area to compensate is about three times higher than for the other two, i.e. 13 ha versus 4 ha for Merwedekanaal and 5 ha for Enecogen. The same was found for the biodiversity offsetting costs of N deposition, which were € 35,952 / yr for Lage Weide, versus € 11,757 / yr for Merwedekanaal and € 12,953 / yr for Enecogen in 2015. These differences can be explained by three factors. To start, the average relative deposition share at the Natura 2000 sites in 2015 is the highest for Lage Weide, i.e. 0.025% versus 0.0096% and 0.021% for respectively Merwedekanaal and Enecogen. Secondly, for Lage Weide it occurred more often that the relatively higher deposition shares were situated in habitat types with comparatively larger surface areas. And thirdly, the exceedance of the CDL by the BD was found to be relatively larger at most habitat types where Lage Weide deposited nitrogen. This resulted in a higher overall contribution and therefore a larger area for which species and habitat types should be compensated by Lage Weide in 2015.

Another thing that stands out when interpreting the results, is that the contribution from Bio Golden Raand to a negative biodiversity impact in Natura 2000 sites was found to be negligible. Therefore no compensation would be required in 2015. Multiple factors play a role in this result. Primarily, in none of the Dutch Natura 2000 sites where N deposition from Bio Golden Raand takes place, the CDL was found to be exceeded by the BD. According to Assumption 5, it was therefore assumed that the conservation status of habitats and species is not directly negatively impacted by the additional N deposition due to electricity and heat production by Bio Golden Raand. In some of the German Natura 2000 sites, the BD does exceed the CDL. However, in none of these sites the deposition by BGR exceeds the deposition limit of 1 mole N ha^{-1} yr^{-1} (Assumption 4). A last reason for this result is that the electricity production as well as the emissions from Bio Golden Raand were significantly lower than from the other power plants. To give an idea of this difference, NO_x emissions from Bio Golden Raand were only 7-17% of the NO_x emissions from the other three plants in 2015.

5.1.2 SENSITIVITY ANALYSIS

The last section of Chapter 4 presented the results of a sensitivity analysis that was performed on the quantitative input parameters and assumptions, to assess their individual impact on the biodiversity offsetting costs of N deposition. The parameters will now be discussed separately.

Deposition limit

The deposition limit is found to be the most sensitive parameter. This had to do with the fact that the deposition limit determines whether a certain amount of deposited N is high enough to be analysed for biodiversity effects. Defining a different deposition limit significantly changes the results because either more or less habitat types are included in the calculations to analyse the biodiversity effects, as can be clearly seen from the graphs. For the purposes of this study it was decided to use the deposition limit above which the Dutch legislation requires projects to have a permit, e.g. a general limit of 1 mole N ha^{-1} yr^{-1} and 0.05 mole N ha^{-1} yr^{-1} for the designated sites in Appendix B [Assumption 4] (Dutch Government, 2015). With the precautionary principle in mind, these deposition limits are found to be sufficient for the purposes of this research since even when adding up such small depositions (< 0.05 mole N ha^{-1} yr^{-1}) from many emission sources, the effects on vegetation are found to be minor (Jasper et al., 2010; Royal HaskoningDHV, 2013). Extensive research on N deposition effects on habitat types and species might provide the possibility to define habitat-specific deposition limits. This would require combining the CDL of habitat types with their conservation status at specific Natura 2000 sites. Using such habitat-specific deposition limits would be preferred over aligning the limit with legislation, since this increases the level of certainty of calculated and/or measured biodiversity effects of N deposition.

Discount rate

The discount rate used in this study is 3%, i.e. the discount rate for large investments in the Dutch economy in 2015 (CPB, 2015). It has to be stated that since this is a yearly given value no actual uncertainty range is applicable. However, since the discount rate is determined annually depending on e.g. inflation and risk (CPB, 2015), it is important to know the sensitivity of the result to this parameter. Varying the discount rate between the realistic values of 1-5% shows a change in the biodiversity offsetting costs of N deposition of about +/- 25%. This is important to take into account when these costs are determined on a yearly basis.

Deposition by Eneco

The outputs of AERIUS are said to have an uncertainty of 30% (Ministry of Economic Affairs, 2013), it was assumed that this uncertainty was distributed normally (i.e. +/- 15%). Variations in these values directly affect the result. The AERIUS model is expected to become more and more accurate in the future, lowering the uncertainties associated to the model outputs (Sutton et al., 2015), among others the level and location of the N deposition of a single company.

Surface area habitat types

It was stated that an uncertainty is present in the measured surface area of the habitat types (Ministry of Economic Affairs, 2015b). The extent of this uncertainty was however unknown, and therefore set at an arbitrary range of +/- 10% in the sensitivity analysis. As expected, varying these values directly affects the result. More accurate delimitation of sites would provide extra information on the amount of affected surface area of the habitat types, and therewith decrease this uncertainty.

Nature construction cost

A major source of uncertainty of the nature construction costs was that costs were only available per nature type and not per habitat type (DLG, 2009). Even though conversions were made with the greatest care (Portaal Natuur en Landschap, 2014, 2015; Staatsbosbeheer et al., 2008), the costs could turn out to be lower or higher in reality. The exact uncertainty of this parameter was however unknown, and therefore set at an arbitrary range of +/- 10% in the sensitivity analysis. As expected, varying these values directly affects the result. More accurate measurements and conversion methods would provide extra information on the nature construction costs, as well as the associated uncertainties.

Background deposition

For each habitat type within the Dutch Natura 2000 sites, a lower and upper boundary value for the background deposition were defined. In 90% of the cases the background deposition of the habitat type either exceeds or is lower than this value, for respectively the lower and upper boundary (AERIUS, 2015; Ministry of Economic Affairs, 2015a). From the sensitivity analysis it becomes clear that the impact of this uncertainty on the final result is very small, i.e. approximately +/- 1%. This has to do with the fact that a higher background deposition does not necessarily mean that the critical deposition load is then exceeded and subsequently shows up in this study's result, and the other way around.

Critical deposition load

The concept of a critical deposition load is criticized by some scientists, since it is very dependent upon other factors of the habitat, such as sulfur load (Raison, Brown, & Flinn, 2001; Wilson, 1988). This could either increase or decrease the height of the CDL. The uncertainty of the CDL of the habitat types was unknown, and therefore set at an arbitrary range of +/- 10% in the sensitivity analysis. In this research, the effect is opposite from varying the BD, since the assumption was made to only include situations if the BD exceeds the CDL. From the sensitivity analysis it becomes clear that the impact of varying the CDL on the final result is very small, i.e. less than +/- 1%. This small sensitivity has to do with the fact that a lower CDL does not necessarily mean that it is then exceeded by the BD and subsequently shows up in this study's result, and the other way around.

5.2 Contribution to literature

In Chapter 2, an overview was provided of various relevant biodiversity impact assessment and compensation methods that can be found in literature. In this study, a protocol was developed to assess the impacts on biodiversity as a result of N deposition caused by business activities. More specifically, the impact at habitat types and species in Natura 2000 sites was reviewed. Furthermore, a method was proposed to determine the biodiversity offsetting costs of N deposition for which the business is responsible.

Overall, it was found that a very important factor in (biodiversity) impact assessment methods is their practicality (Quétier & Lavorel, 2011), in particular regarding time and budget constraints of businesses (McKenney, 2005) and their request for a strong legal basis. This requires consistency and repeatability of the assessment method (Fennessy, Jacobs, & Kentula, 2007). Attention was paid to these issues while developing this study's methodology.

A few major differences can be noticed when comparing the protocol that was developed in this study with the ReCiPe method (Goedkoop et al., 2013). Primarily, ReCiPe takes into account the whole supply chain. This also is the aim of this study, however for pragmatic reasons mentioned in Chapter 3, in the case studies only the operational phase was included. Furthermore, ReCiPe measures biodiversity impacts by modeling the dispersion of emissions and dose/effect relations for the species that are found to be exposed to these emissions (Croezen et al., 2014). It would be interesting to expand this study with such a model, since at this moment it is only reviewed if the species are exposed to the emissions and whether they are dependent upon N sensitive habitat types. This study does however include data on spatial distribution of N sensitive species and habitats (AERIUS, 2015; Ministry of Economic Affairs, 2015c), which is lacking in ReCiPe. Lastly, in this study impacts are measured at a local and regional level, whereas ReCiPe only measures global impacts (Goedkoop et al., 2013; Lammerant et al., 2016).

Compared to the GLOBIO model (PBL, 2016) this protocol does provide the opportunity of expressing the absolute impact of the company at biodiversity. GLOBIO merely expresses the relative biodiversity impact of various policy alternatives (Croezen et al., 2014).

According to Rockström et al. (2009) and Steffen et al. (2015) the biodiversity boundary is currently measured in extinctions per million species-years (E/MSY). For this study's purpose, expressing the impact of N deposition at biodiversity in terms of the relation between N emissions and extinction rate can be very interesting. There are however some issues in the feasibility of this. First of all, it should be clear to wat extent the extinction of the species is caused solely by N emissions. Subsequently, in the planetary boundaries framework extinction is reviewed at a global level, whereas the effect of N emissions are mostly local and regional. Clearly, more research is required to be able to quantify this relationship as such.

When comparing this study's result with the method that was developed by Lammerant et al. (2016), three main components are added. First of all, for specific designated Natura 2000 sites that have at least 95% of the still available space for additional N deposition already covered by reports submitted to PAS, the deposition limit is set at 0.05 mole N ha^{-1} yr^{-1}, in line with Dutch legislation (Dutch Government, 1998, 2015). This way, the current state of the Natura 2000 sites is also taken into account in the evaluation. Secondly, the impact for which individual companies are responsible is added, by calculating the share in total deposition per habitat type. This made it possible to also add a third component, i.e. translating this responsible impact into a compensation budget that reflects the biodiversity offsetting costs of N deposition.

This third point makes use of the concept of natural capital accounting, i.e. putting a monetary value on the biodiversity impact (Natural Capital Coalition, 2016; Spurgeon, 2014). What is however new, is that nature compensation cost, i.e. biodiversity offsetting, is used as a capitalization method (Inamdar, Jode, Lindsay, & Cobb, 1999; Toly, 2004). These so called biodiversity offsetting costs of N deposition are proposed to be used as a budget to offset the biodiversity impact in the most cost-effective way (Schouten et al., 2012). This does not necessarily have to be the creation of new habitats. Morris et al. (2006) found that creating new terrestrial habitats as means of offsetting cannot be seen as a consistent and reliable compensation method for sustainable development. This is in line with the recommendations for compensation that are given in this study.

5.3 Limitations of the research

5.3.1 PROTOCOL

Regarding the developed protocol there are three major concepts that require some discussion, i.e. (1) the approach for N deposition in other countries than the Netherlands, (2) the assumption to only review the impact of N deposition for Natura 2000 sites and for species designated under the Birds and/or Habitats directives (European Commission, 1992, 2009), and (3) the approach that was used to determine the biodiversity offsetting costs of N deposition. This is briefly discussed in the next three paragraphs. Further reviewing of these points is recommended to create a consistent and universally applicable methodology for assessing the biodiversity impacts of N deposition, as well as the associated biodiversity offsetting costs.

The protocol for assessing the effects of N deposition on biodiversity was initially developed for the Netherlands. This means that this exact methodology is not necessarily directly applicable to other countries. First, the AERIUS tool, which is the basis of the data collection step, is developed for The Netherlands only. Belgium uses a similar instrument, i.e. IMPACTSCORE NH3, which does not include NO_x emissions. This makes it difficult to collect the deposition data that is necessary for applying the protocol in other countries. Furthermore, other areas in the world have habitat types for which no critical load is yet defined (Van Dobben et al., 2012). Extra habitat-specific CDLs would have to be researched and added to the model to make it applicable to other situations than the Netherlands. Lastly, to determine the biodiversity offsetting costs of N deposition this protocol uses the costs of creating nature of specific nature types as defined for the Natura 2000 sites of the Netherlands (DLG, 2009). Not all habitat types that exist in other countries are compatible with these Dutch nature types (Portaal Natuur en Landschap, 2015; Staatsbosbeheer et al., 2008) and therefore a different approach is needed to determine associated construction costs. This research has tackled this problem by calculating the costs of separate construction measures (Verburg et al., 2016) for each foreign habitat type where N was deposited by Eneco, see Appendix C.IV.

Step 2 of the protocol determined which Natura 2000 sites suffer from deposition by the company. It was a pragmatic decision to limit the impact area to Natura 2000 sites, since AERIUS only allows to model for these areas. In reality, however, also nature which is not included in the Natura 2000 network suffers from negative biodiversity effects of N deposition. For the Netherlands, at least the areas that are identified for the ecological network (EHS) (Portaal Natuur en Landschap, 2014) should be included in the model to reflect the actual biodiversity impact more accurately. Step 4 of the protocol determined for each habitat type which species are present that could be vulnerable to N deposition. For pragmatic reasons, i.e. availability of compatible databases, only species are taken into account that are designated under the Birds and/or Habitats Directive (European Commission, 1992, 2009). It is acknowledged that this demarcation might not include all threatened species, especially regarding vegetation and insects, so a more detailed determination of present species and their conservation status would make it possible to define the biodiversity impacts more accurately. A first step could be to, in addition to species that are protected under the flora- and fauna law, include the home range of red list species (IUCN, 2015) in the model calculations.

Finally, the biodiversity offsetting costs of N deposition in Step 7 could theoretically also be determined by taking a completely different approach, unrelated to the costs of constructing new nature. Ideally, for each habitat type affected by N deposition it should be separately determined what needs to be done to return the specific habitat type to its original state and what costs would be associated to this. Such a tailor-made approach would however be very time-consuming and the likelihood of encountering data gaps and inconsistencies is large. A more universal approach, as was developed in this study, is therefore still preferred. To provide an idea of a possible implementation of the biodiversity offsetting budget, this section shows the costs associated to a specific mitigation or compensation measure, e.g. reducing N deposition. Chapter 2 introduced a stepwise approach that Schouten et al. (2012) identified to reduce N deposition. The costs increase per unit of N removal. Firstly it is assumed that N deposition reduces by companies going out of business. Secondly, generic deposition measures are taken (e.g. reducing emissions from agriculture, industry, traffic) and thirdly local deposition measures are taken (e.g. relocating agricultural companies, installing air cleansers). If the critical load is still exceeded, effect oriented measures are taken (e.g. actively reducing N deposited at nature sites). These are intensive measures that can be taken only once per generation to remove the excessive N (i.e. BD – CDL). For the effect oriented measures Schouten et al. (2012) have determined the annual costs for intensified nature conservation management, varying between 0.05 and 0.30 € / mole N / ha / yr. These are compatible with the nature type classification according to Appendix C.V (Van der Hoek, Van Hinsberg, Van Esbroek, & Reijnen, 2008). However, based on a study of Sival et al. (2002) and the fact that the effect oriented measures were expected to cost more than the other N reduction measures, Schouten et al. (2012) state in their discussion that these costs are significantly underestimated and should be multiplied by a factor 23. The following formula would be used to determine the annual costs of N reduction by taking effect oriented measures in all affected Natura 2000 sites with different habitat types, leading to the expenditures as presented in Table 5-1:

$$N\ reduction\ costs\ of\ effect\ oriented\ measures\ [€\ yr^{-1}] = 23 * \sum_{i=1}^{n} Affected\ surface\ area\ _i[ha] * (BD_i - CDL_i\ )[mole\ N\ ha^{-1}yr^{-1}] * N\ reduction\ cost_i[€/(mole\ N\ ha^{-1}yr^{-1})]$$

For which:

i = all habitat types ($i_1, i_2 \ldots n$) situated in Natura 2000 sites where 1) deposition Eneco > 1 mole N ha^{-1} yr^{-1} or 0.05 mole N ha^{-1} yr^{-1} in the designated Natura 2000 sites, and 2) BD > CDL.

The costs of this measure are only a fraction of the biodiversity offsetting budget, i.e. 13-14%. It is important to mention that purchasing the land was not included in this calculation. This is only one of the measures that could be used in practice and is not by definition the most effective and universally applicable measure. However, for the purposes of this research this does give insight in the order of magnitude of the costs associated to a single measure.

Table 5-1: N reduction costs of effect oriented measures in 2015, at all habitat types situated in Natura 2000 sites in the Netherlands where 1) N deposition Eneco > 1 mole N $ha^{-1}yr^{-1}$ or > 0.05 mole N $ha^{-1}yr^{-1}$ in the designated Natura 2000 sites, and 2) BD > CDL.

N reduction costs at affected Natura 2000 area in 2015	Lage Weide (2015)	Merwedekanaal (2015)	Enecogen (2015)	Bio Golden Raand (2015)
Total [€ yr^{-1}]	13,272,955	10,500,420	11,257,212	0
Responsible share Eneco [€ yr^{-1}]	5,083	1,518	1,725	0

5.3.2 SUPPLY CHAIN

This study has only taken into account the operational phase of Eneco's power plants. In practice, however, N emissions also take place during other activities throughout the supply chain. This study did not take these into account due to the very local nature of N deposition and the difficulty of modeling this, as well as the relatively small contribution at specific sites. In reality this does of course contribute to the total N deposition, may it only be little, but many small contributions can still add up to a significant effect. It is recommended to further develop N deposition modeling software in order to also include the effects of these emissions.

A first start could be to include all N emissions related to the sourcing of the fuel, for which a significant contribution of biomass can be expected (Di & Cameron, 2002). Also the NO_x that is emitted during the transport of gas, biomass and other materials to the power plant can be measured and modeled (Kristensen, 2002), to include this in the assessment.

Furthermore, the N emissions caused by households as a result of local combustion of gas can be added to the model. If supplied by Eneco, this is part of Eneco's supply chain. In 2013, Dutch households consumed 358.93 PJ (or 99.7 TWh) of natural gas (CBS, 2016). The biodiversity impact from associated N emissions is expected to be far from negligible. Eneco covers about 25% of this market (Eneco, 2016). The AERIUS model was not suitable to map these depositions, since the exact location of all separate emission points is needed. Including this in the calculator would have been a very time-consuming task, neither was the exact data readily available.

5.3.3 BIODIVERSITY OFFSETTING

Ideally, a company's emissions should be avoided and mitigated in such a way that offsetting the negative impacts is not necessary, according to the mitigation hierarchy (PricewaterhouseCoopers, 2010; Rio Tinto, 2013). If offsetting remains necessary, compensation should ideally take place exactly for what has been degraded as a result of the business's activities. In practice however the impact is distributed over many different habitat types, and every type of nature has a different value; different habitats, species and ecosystem services that depend upon it. Furthermore, the local nature of N deposition effects (Vitousek et al., 1997) would require compensation to take place at a local level, which in practice is very complex and not always desirable due to among others occupation of land for other purposes (Moeller & Hvingel, 2006). Therefore Step 7 of the protocol determined a budget based on the costs of constructing new nature, i.e. the biodiversity offsetting costs of N deposition. Five types of measures were identified in Chapter 3 that can contribute to compensation of the negative biodiversity impacts from N deposition. It should however be kept in mind that this budget has to be distributed over many different habitat types that are affected by the company.

Allocation procedure

A next step should then be to define an allocation procedure, that helps to distribute the defined budget over these measures and the affected sites in the most cost-effective way. Since many different habitat types are affected and to various levels, prioritization is required. This means that for example preference should be given to the habitat types and species with an unfavourable conservation status, habitats were the CDL is already exceeded and to areas that are expected to benefit the most from a specific measure. Also, it should be reviewed to what extent quality and quantity of a habitat are interchangeable. It is therefore recommended to expand the protocol with a cost-effectivity analysis, that identifies the most effective compensation measure(s) based on the characteristics and conservation status of the affected sites. Apart from that, expert opinions will still be required on a case by case basis to identify the most viable option.

Compensation measures

Ideally, all stakeholders that contribute to N deposition in the affected area should contribute to the compensation, according to their share in the deposition. This would require an integrated stakeholder approach, which would enable to establish an offsetting budget reflecting the biodiversity offsetting costs of N deposition per affected site and not just for one company. With the cost-effectivity analysis that was introduced above, the most effective measures should then be implemented at the affected sites taking into account the distribution over the different habitat types as discussed earlier. A few examples of compensation measures are given here, more research is needed on the details and applicability to specific situations:

- *Contribution to additional management measures of affected Natura 2000 sites.* Eneco can financially contribute to additional nature management to maintain or develop a favourable conservation status of the habitats and species. To establish this, the person responsible for the management in the affected Natura 2000 site needs to be consulted in order to determine whether this is a viable option. It is important that the measures are additional, and not merely a shift in takes place in who pays for the measure. This would not provide benefit to nature and would be classified as greenwashing.
- *Contribution to additional nature conservation measures that minimize nitrogen effects at the affected area, albeit not directly related to the company's N deposition.* The most relevant example of such a measure is combating drought, as drought can lead to a lower resistance to N deposition (i.e. lower CDL) (Bobbink, Ashmore, et al., 2002; Ministry of Economic Affairs, 2016a). This can result in e.g. acidification, increased drought and fragmentation of habitats, further stimulating biodiversity loss (Steffen et al., 2015). This effect can be lowered by reducing the drought in areas around the Natura 2000 site to create a buffering zone (Hefting et al., 2004). Two types of costs are related to combating drought: firstly the costs associated to the hydrological activities to increase the groundwater level (costs per ha are known), and secondly agricultural yield depression, i.e. the financial agricultural losses that are a consequence of this since the land can now only be used for extensive cattle grazing (Schouten et al., 2012). These costs are very location dependent. Similar measures could be designed for combating acidification in an area (Bobbink, Ashmore, et al., 2002). Eneco could financially contribute to this.
- *Contribution to additional technological developments to decrease overall N emissions from multiple sectors.* Eneco can invest in technological research to further decrease N emissions related to its own practices, for example by improving DeNOx filters, reducing the amount of NH_3 that is required for the combustion process or reducing N available in the fuel. Furthermore, N emissions from other sectors can be reduced by investing in technology, e.g. air cleansers at livestock stables or applying fertilizers more efficiently. The latter might be more effective in specific Natura 2000 sites.
- *Contribution to N reducing measures in affected Natura 2000 sites.* It was previously explained under 5.2 Protocol that according to Schouten et al. (2012) the last measure that is commonly used to reduce N deposition is reducing the amount of N in the ground, i.e. effect oriented measures. The associated costs were calculated in Table 5-1 for the cases that were handled in this research. If this is the most effective measure, Eneco could

financially contribute to compensate for its negative impacts.

- *Actual one-on-one compensation of the impacted area, i.e. land of similar quality and surface area.* This would require construction of new nature, on which the calculation method for the biodiversity offsetting budget is based, or at least maintaining a certain conservation status at a specific type of nature. In practice such an area could be registered to ensure the ecological quality (Hannah et al., 2007). The VCA-register (Verified Conservation Area) could be very well suitable for this, providing transparency on the management practices as well as the possibility for third parties to co-invest in the maintenance and recovery of the ecology and biodiversity. Annual audits are required to ensure monitoring of the conservation status (VCA, 2016).

5.4 Recommendations for further research

The previous sections provided the major recommendations for further research related to the assessment of N deposition impact, i.e. the applicability of the protocol to the situation in other countries and sectors; a detailed assessment of characteristics of the N sensitive habitat types and species; impacts of N emissions from other activities throughout the supply chain; researching the most appropriate method to determine the biodiversity offsetting costs of N deposition, and; research on the most effective compensation measures for each situation. This section adds to this by providing further recommendations for research related to biodiversity impact assessment in general.

It is proposed to expand the protocol by including other pressure factors that influence biodiversity. Figure 2-1 in Chapter 2 summarizes the pressure factors that relate to biodiversity loss. Relevant pressure factors in the energy sector are noise and light emissions and barrier / collision effects. Expanding the protocol by adding these (and ideally more) pressure factors would make it possible to also determine the biodiversity impacts of other assets in the energy sector, e.g. solar and wind energy units.

On the whole, measuring a business's impact on biodiversity is a complex task. If all up- and downstream impacts would be included, the data requirement and therewith the chance that data might not be available is large. Linking the impacts of an individual company directly to the extinction risk of a certain species is extremely difficult, because species are rarely impacted in just one region, by one company and/or by one type of pressure factor. This relates to the fact that cumulative impacts can be very important, since biodiversity loss and ecosystem degradation can be increased by combined impacts. However, not all correlations between pressures are known. In this light, further research is proposed on effects of correlating and combined pressures, whether these effects take place at local, regional or global level, to what extent cumulation plays a role in this and the relative sensitivity of species and habitats to these pressures.

Lastly, it is proposed to review the protocol that was developed in this study in relation to the concept of ecosystem services and natural capital accounting, as was briefly touched upon in Chapter 2. This study has tried to put a monetary value on the environmental impact from N deposition, which is also the approach taken in natural capital accounting (Spurgeon, 2014). The ecosystem services concept might provide further guidance in expanding the protocol for depositions abroad, other pressure factors or determining the most effective compensation measures.

6 CONCLUSION

In this study, a protocol was developed to assess the impacts on biodiversity as a result of N deposition caused by business activities. More specifically, the impact at habitat types and species in Natura 2000 sites was reviewed. Furthermore, a method was proposed to determine the biodiversity offsetting costs of N deposition for which the business is responsible. The methodology was tested by applying it to N emissions from electricity and heat producing gas and biomass power plants, operated by Eneco.

In 2015, the power plants of Lage Weide, Merwedekanaal, Enecogen and Bio Golden Raand have together produced 4,368,693 MWh electricity, causing 764,108 kg NO_x and 2,451 kg NH_3 emissions in the production phase. Each power plant separately contributed to a negative impact at the biodiversity values in the Natura 2000 sites in the Netherlands, Germany and Belgium where the background deposition exceeds the critical deposition load, for depositions higher than 1 mole N ha^{-1} yr^{-1} and 0.05 mole N ha^{-1} yr^{-1} in the Natura 2000 sites that already suffer from high N deposition (Appendix B). In 2015 Lage Weide, Enecogen and Merwedekanaal contributed in a similar way to the amount of affected hectares, Natura 2000 sites, habitat types and species as a result of their N deposition. Bio Golden Raand was found to have a negligible impact on all biodiversity values under the assumptions taken.

From the total area of habitat types within Natura 2000 sites that have a negative biodiversity impact as a result of N deposition, the responsible share of Eneco was determined. Taking the relative exceedance of the CDL and the deposition share of Eneco in all habitat types into account, Eneco was responsible for a total of 23 ha at which species and habitats were negatively impacted in 2015. These hectares are distributed over many different types of habitats throughout the Netherlands.

In the light of OPT, Eneco wishes to compensate for its negative impacts on the environment. Therefore the biodiversity offsetting costs of N deposition from electricity and heat production by Eneco were calculated. This calculation was based on the costs that would be associated with the construction of new nature, taking into account the characteristics of the different affected habitat types. For 2015, the biodiversity offsetting costs for which Eneco is responsible were found to be € 60,662.

These costs will return on a yearly basis, assuming constant efficiency and production. The budget should be deployed in a cost-effective way to reduce the negative biodiversity impacts from N deposition and to maintain or improve the conservation status of the affected Natura 2000 site(s). The most cost-effective compensation measure should be applied first, while giving preference to the habitat types and species that have an unfavourable conservation status. Further research is recommended to provide detailed guidelines on how this should be accomplished in practice.

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8 APPENDICES

A. Software - AERIUS Calculator

AERIUS Calculator is based on the Operational Priority Substances (OPS) model. This model was first described in a thesis (Van Jaarsveld, 1995). Over the past years it is updated to the current model (Sauter et al., 2016). First, AERIUS Calculator will be briefly introduced, followed by a paragraph on the validation of the model and the most important assumptions and calculations.

Retrieved from https://www.aerius.nl/en/about-aerius/products/aerius-calculator, June 13 2016:

> *On 15 December 2015 AERIUS Calculator 2015 was officially released for production.*
>
> *…*
>
> *AERIUS Calculator is the calculation tool used for determining the nitrogen emissions from a certain source, their dispersion in the air and their deposition on Natura 2000 areas. Calculator also shows the magnitude of the impact on nitrogen-sensitive habitats. The user merely enters a number of characteristics for his or her project, such as spatial location, type of activity and the altitude at which nitrogen will be emitted.*
>
> *…*
>
> ***Fields of application***
>
> *Calculator calculates for agriculture, industry, residential housing, offices and shops, waste treatment plants, power plants, mobile machinery, sea shipping and inland shipping, and road, air and railway traffic.*
>
> *…*
>
> ***Data and methods***
>
> *AERIUS contains all the basic data needed for calculation. The user therefore no longer needs to collect information and is always ensured of using the right maps and data. This concerns, for example, the map of nitrogen-sensitive habitats in Natura 2000 areas, and the base map that contains nitrogen background deposition calculated by the RIVM (GCN/GDN maps; in Dutch).*
>
> *The core of the AERIUS calculation tool is formed by RIVM's Operational Priority Substances model (OPS). This model calculates the dispersion of nitrogen in the air and its deposition. In doing so, OPS takes various factors into account that may influence the dispersion and deposition of nitrogen, such as wind direction and speed, terrain roughness and vegetation height. For road traffic, AERIUS uses the Standard Calculation Method 2 (SRM2). Here, AERIUS is in line with the modelling method used in the Dutch national air quality plan 'Nationaal Samenwerkingsverband Luchtkwaliteit'.*

In 2015, a review was done on the scientific underpinning of calculation of ammonia emission and deposition in the Netherlands (Sutton et al., 2015). It was found that "On the whole, the methods used in the Netherlands for emission estimation, measurement and modelling of atmospheric ammonia are generally sound. … Dutch dispersion and deposition modelling can be considered as well fitted for assessment of regional spatial patterns. … However, there are concerns regarding the analysis of long-term trends, especially given that current trends are now starting to flatten out following implementation of the most effective measures" (Sutton et al., 2015).

It would be impossible to include all principles that underlie the AERIUS Calculator (Sauter et al., 2016) in this appendix. Therefore the assumptions that were found most important for the emissions from the electricity sector (e.g. assumptions relating to wind patterns) and associated calculations of important parameters are presented here. For a complete overview of the underlying principles of AERIUS, see Sauter et al. (2016).

Assumptions

"The OPS model is designed to make use of the standard and routinely available meteorological data." The meteorological parameters are "wind direction and wind speed at two heights, precipitation data, global radiation (or cloud cover), temperature and snow cover, all measured at one or more locations in the Netherlands."

The Netherlands is divided into six meteorological districts, based on wind patterns, for which OPS separately loads the primary meteorological data. "All necessary meteorological input data is obtained from the KNMI. … The data is first interpolated over the Netherlands, using all the available weather stations, and then calculating district averages."

For wind, all observations in the Netherlands are combined into an average wind vector, that is assumed to be representative for an area at least twice the size of the Netherlands.

The influence of obstacles (e.g. buildings) on the dispersion of the emissions is modeled by assuming a homogenous distribution of these obstacles, expressed in terms of terrain roughness. The terrain roughness can be set in the grid.

In calculating the contribution from local sources, the height of the emission source plays an important role due to convective turbulent mixing in the lower atmosphere caused by solar radiation. The mixing height of the atmosphere varies from 50 (stable atmosphere) to 2000 m (unstable atmosphere), determining when and where the emissions are deposited. In the model a fixed vertical structure of the lower atmosphere is used to determine the distribution of the concentrations (Figure 1.6, (Sauter et al., 2016)).

The cloud cover is computed depending on the latitude of the location. In OPS the location of De Bilt is used (latitude 52˚).

From the above, averaged direction and distance parameters are created that can be applied as an effective path ratio (fp_{eff}) to determine where emissions from a specific source deposit.

For all sectors that are included in AERIUS, the time-dependent emission behavior is specified as a daily variation. This is specified in the local time zone at the source location. For the industrial sector, the intensity of activities is relatively stable over the day.

Calculations

Spatial averaging of wind speed, global radiation, temperature, humidity, precipitation duration and intensity is done by an interpolation formula, independent of wind direction:

Interpolation formula for grid cell (k,l), x_{kl} for parameters measured by KNMI stations:

$$x_{kl} = \frac{\sum_{i=1}^{N} w(i)x(i)}{\sum_{i=1}^{N} w(i)}$$

With x(i) being the parameter value at station i and w(i) the weighting factor for station i:

$$w(i) = exp\left[\frac{-r}{r_{rep}}\right]$$

With r being the distance between the grid point and station i, and r_{rep} being the mean distance between the station, fixed at 10km.

Spatial averaging of wind direction: "The potential wind speed u in combination with the wind direction is split into an u_x and u_y vector and district averages are computed as above for u_x and u_y. The resulting wind direction per district is simply calculated by taking the arctangent of the vectors."

B. Deposition limits Natura 2000 sites (PAS)

The general deposition limit above which a permit is required is 1 mole N ha^{-1} yr^{-1}. For specific designated Natura 2000 sites that have at least 95% of the still available space for additional N deposition already covered by reports submitted to PAS, the deposition limit is 0.05 mole N ha^{-1} yr^{-1} (Dutch Government, 1998, 2015). This appendix provides an overview of the Natura 2000 sites that have a deposition limit of 0.05 mole N ha^{-1} yr^{-1} ((PAS-bureau, 2016), http://pas.bij12.nl/content/mededeling-over-de-ruimte-voor-meldingen). For all Natura 2000 sites that are not included in Table 8-1 it can be assumed that the deposition limit is 1 mole N ha^{-1} yr^{-1}.

Table 8-1: Natura 2000 sites with a deposition limit of 0.05 mole N ha^{-1} yr^{-1} (PAS-bureau, 2016).

SITECODE	SITENUMBER	SITENAME	Date at which the deposition limit has been adjusted to 0.05 mole N ha^{-1} yr^{-1}
NL3009001	13	Alde Feanen	12-18-2015
NL2003028	21	Lieftinghsbroek	01-07-2016
NL3000036	103	Nieuwkoopse Plassen & De Haeck	01-14-2016
NL3009006	6	Duinen Schiermonnikoog	01-14-2016
NL2014038	38	Rijntakken	01-15-2016
NL9801080	87	Noord-Hollands Duinreservaat	02-09-2016
NL2003029	51	Lonnekermeer	02-18-2016
NL9801019	53	Buurserzand & Haaksbergerveen	02-29-2016
NL3004006	105	Zouweboezem	03-31-2016
NL3009017	57	Veluwe	04-20-2016
NL1000028	145	Maasduinen	04-26-2016

C. Nature types and foreign habitat types

I. COMPATIBILITY NATURE TYPES AND NATURA 2000 HABITAT TYPES

Table 8-2: Compatibility of Dutch nature types (N01-N17) with habitat types present in the Netherlands (Portaal Natuur en Landschap, 2014, 2015; Staatsbosbeheer et al., 2008)**. For the habitat types that can possibly be allocated to multiple nature types, the most obvious combination was used in this study.**

Nature types				Habitat types (Natura 2000)	
N01	Grootschalige dynamische natuur	N01.01	Grootschalig zout (getijden)water	H1110	Permanent overstroomde zandbanken
				H1130	Estuaria
				H1140	Slik- en zandplaten
				H1160	Grote baaien
				H1170	Riffen van open zee
		N01.02	Grootschalig duin- en kwelderlandschap		

Nature types				Habitat types (Natura 2000)	
		N01.03	Grootschalige rivier- en moeraslandschap		
		N01.04	Grootschalige zand- en kalklandschap		
N02	Rivieren	N02.01	Rivier	H3260	Beken en rivieren met waterplanten
				H3270	Slikkige rivieroevers
N03	Beken en bronnen	N03.01	Beek en bron	Lg01	Permanente bron & Langzaam stromende bovenloop
N04	Stilstaande wateren	N04.01	Kranswierwater	H3140	Kranswierwateren
		N04.02	Zoete plas	H3150	Meren met krabbenscheer en fonteinkruiden
		N04.03	Brak water		
		N04.04	Afgesloten zeearm		
N05	Moerassen	N05.01	Moeras	H7210	Galigaanmoerassen
				Lg05	Grote-zeggenmoeras
		N05.02	Gemaaid rietland	H6430	Ruigten en zomen
N06	Voedselarme venen en vochtige heiden	N06.01	Veenmosrietland en moerasheide	Lg07	Dotterbloemgrasland van veen en klei
		N06.02	Trilveen	H7140	Overgangs- en trilvenen
		N06.03	Hoogveen	H7110	Actieve hoogvenen
				H7120	Herstellende hoogvenen
		N06.04	Vochtige heide	H4010	Vochtige heiden
				H7150	Pioniervegetaties met snavelbiezen
		N06.05	Zwakgebufferd ven	H3110	Zeer zwakgebufferde vennen
				H3130	Zwakgebufferde vennen
				Lg02	Geïsoleerde meander en petgat
				Lg03	Zwakgebufferde sloot
		N06.06	Zuur ven of hoogveenven	H3160	Zure vennen
				Lg04	Zuur ven
N07	Droge heiden	N07.01	Droge heide	H2310	Stuifzandheiden met struikhei
				H2320	Binnenlandse kraaiheibegroeiingen
				H4030	Droge heiden
				H5130	Jeneverbesstruwelen
				H6230	Heischrale graslanden
		N07.02	Zandverstuiving	H2330	Zandverstuivingen
N08	Open duinen	N08.01	Embryonaal duin en strand	H2110	Embryonale duinen
		N08.02	Open duin	H2120	Witte duinen
				H2130	Grijze duinen
		N08.03	Vochtige duinvallei	H2170	Kruipwilgstruwelen
				H2190	Vochtige duinvalleien
		N08.04	Duinheide	H2140	Duinheiden met kraaihei
				H2150	Duinheiden met struikhei
				Lg12	Zoom, mantel en droog struweel van de duinen

Nature types				**Habitat types (Natura 2000)**	
N09	Schorren of kwelders	N09.01	Schor of kwelder	H1310	Zilte pionierbegroeiingen
				H1320	Slijkgrasvelden
				H1330	Schorren en zilte graslanden
N10	Vochtige schraalgraslanden	N10.01	Nat schraalland	H6410	Blauwgraslanden
				H7230	Kalkmoerassen
				Lg06	Dotterbloemgrasland van beekdalen
		N10.02	Vochtig hooiland	Lg08	Nat, matig voedselrijk grasland
N11	Droge schraalgraslanden	N11.01	Droog schraalgrasland	H6110	Pionierbegroeiingen op rotsbodem
				H6120	Stroomdalgraslanden
				H6130	Zinkweiden
				H6210	Kalkgraslanden
				H6230	Heischrale graslanden
				Lg09	Droog struisgrasland
N12	Rijke graslanden en akkers	N12.01	Bloemdijk		
		N12.02	Kruiden- en structuurrijk grasland		
		N12.03	Glanshaverhooiland	H6510	Glanshaver- en vossenstaarthooilanden
				Lg10	Kamgrasweide & Bloemrijk weidevogelgrasland van het zand- en veengebied
		N12.04	Zilt grasland en overstromingsweiland	H1330	Schorren en zilte graslanden
		N12.05	Kruiden- en faunarijke akker		
		N12.06	Ruigteveld	H6430	Ruigten en zomen
N13	Vogelgraslanden	N13.01	Vochtig weidevogelgrasland	Lg11	Kamgrasweide & Bloemrijk weidevogelgrasland van het rivieren- en zeekleigebied
		N13.02	Wintergastenweide		
N14	Vochtige bossen	N14.01	Rivier- en beekbegeleidend bos	H7220	Kalktufbronnen
				H91E0	Vochtige alluviale bossen
				H91F0	Droge hardhoutooibossen
		N14.02	Hoog- en laagveenbos	H91D0	Hoogveenbossen
		N14.03	Haagbeuken- en essenbos	H9160	Eiken-haagbeukenbossen (hogere zandgronden)
N15	Droge bossen	N15.01	Duinbos	H2160	Duindoornstruwelen
				H2180	Duinbossen
				Lg13	Bos van arme zandgronden
		N15.02	Dennen-, eiken- en beukenbos	H9110	Veldbies-beukenbossen
				H9120	Beuken-eikenbossen met hulst
				H9190	Oude eikenbossen
				Lg14	Eiken- en beukenbos van lemige zandgronden
N16	Bossen met productiefunctie	N16.01	Droog bos met productie	H91F0	Droge hardhoutooibossen
		N16.02	Vochtig bos met productie		
N17	Cultuurhistorische bossen	N17.01	Vochtig hakhout en middenbos		
		N17.02	Droog hakhout		

Nature types			Habitat types (Natura 2000)
	N17.03	Park- en stinzenbos	
	N17.04	Eendenkooi	
	N00	Nog te vormen naar natuur	

II. LAND PRICE

Table 8-3: Price per ha for purchasing land for the ecological network, per province of the Netherlands and separately for Germany and Belgium (Eurostat, 2012; Schouten et al., 2012).

Province[1]	Price of Land (€/ha)
Groningen	23100
Friesland	22900
Drenthe	20700
Overijssel	29800
Gelderland	35400
Flevoland	42500
Utrecht	42000
Noord-Holland	31000
Zuid-Holland	37100
Zeeland	32900
Noord-Brabant	40900
Limburg	34700
Germany	8909
Belgium	27190

[1] Land price Provinces NL from Schouten et al. (2012), based on data from DLG. Land price Germany and Belgium from Eurostat (2012): Land prices and rents, price for agricultural land in 2006. For the Netherlands Eurostat gives €47,051 per ha.

III. NATURE CONSTRUCTION COSTS

Table 8-4: Average standardized costs per hectare for construction of new nature in the Netherlands, specified per nature type (DLG, 2009; Schouten et al., 2012).

#	Nature type to be constructed	Average standardized costs in NL [€/ha]
N01.01	Grootschalig zout (getijden)water	*n/a*
N01.02	Grootschalig duin- en kwelderlandschap	*n/a*
N01.03	Grootschalige rivier- en moeraslandschap	*n/a*
N01.04	Grootschalige zand- en kalklandschap	*n/a*
N02.01	Rivier	*52,141*
N03.01	Beek en bron	*63,259*
N04.01	Kranswierwater	*60,931*
N04.02	Zoete plas	*77,749*
N04.03	Brak water	*56,071*
N04.04	Afgesloten zeearm	*n/a*
N05.01	Moeras	*49,462*
N05.02	Gemaaid rietland	*49,462*
N06.01	Veenmosrietland en moerasheide	*34,336*
N06.02	Trilveen	*60,931*
N06.03	Hoogveen	*43,138*
N06.04	Vochtige heide	*45,270*
N06.05	Zwakgebufferd ven	*51,700*

N06.06	Zuur ven of hoogveenven	*51,700*
N07.01	Droge heide	*39,869*
N07.02	Zandverstuiving	*37,003*
N08.01	Embryonaal duin en strand	*n/a*
N08.02	Open duin	*n/a*
N08.03	Vochtige duinvallei	*54,245*
N08.04	Duinheide	*n/a*
N09.01	Schor of kwelder	*35,633*
N10.01	Nat schraalland	*40,349*
N10.02	Vochtig hooiland	*36,705*
N11.01	Droog schraalgrasland	*29,064*
N12.01	Bloemdijk	*11,640*
N12.02	Kruiden- en structuurrijk grasland	*8,242*
N12.03	Glanshaverhooiland	*14,651*
N12.04	Zilt grasland en overstromingsweiland	*19,787*
N12.05	Kruiden- en faunarijke akker	*10,480*
N12.06	Ruigteveld	*6,504*
N13.01	Vochtig weidevogelgrasland	*6,936*
N13.02	Wintergastenweide	*5,733*
N14.01	Rivier- en beekbegeleidend bos	*9,256*
N14.02	Hoog- en laagveenbos	*25,829*
N14.03	Haagbeuken- en essenbos	*22,357*
N15.01	Duinbos	*24,922*
N15.02	Dennen-, eiken- en beukenbos	*23,798*
N16.01	Droog bos met productie	*24,124*
N16.02	Vochtig bos met productie	*23,733*
N17.01	Vochtig hakhout en middenbos	*23,394*
N17.02	Droog hakhout	*23,363*
N17.03	Park- en stinzenbos	*24,745*
N17.04	Eendenkooi	*n/a*
N00	Nog te vormen naar natuur	*n/a*

IV. FOREIGN HABITAT TYPES

In the foreign Natura 2000 sites, new habitat types were present for which information on the CDL and the standardized costs for constructing new nature were unknown. Differences in costs exist per region and per nature type, due to varying intensities of construction activities, e.g. soil removal, water works, sowing seeds and planting of saplings. Information on these costs and the fraction per type of land from Verburg et al. (2016) is presented in Tables 8-5 and 8-6.

Table 8-5: Assumed CDL and costs for construction of nature for foreign habitat types (Verburg et al., 2016).

Habitat-code	Habitatname	CDL [mole N ha^{-1} yr^{-1}]	Approach	Nature construction cost [€/ha]	Approach, formulas refer to Table 8-5 and 8-6
H1150	Coastal lagoons	2,400	Characteristics similar to H1110-H1170	0	n/a
H1340	Inland salt meadows	1,571	Characteristics similar to H1340	27,287	Inland marshes * (Type 1 + Type 2)
H6520	Mountain hay meadows	1,571	Characteristics similar to H6510	28,381	Moors and heat lands * (Type1 + Type 3 + Type 9)

H7120	Degraded raised bogs still capable of natural regeneration	500	Characteristics similar to H7120ah	38,807	Peat bogs * (Type 1 + Type 2 + Type 3)
H8210	Calcareous rocky slopes with chasmophytic vegetation	2,143	Medium-high acid neutralizing ability (Glass et al., 1982; Tao & Feng, 2000)	0	n/a
H8220	Siliceous rocky slopes with chasmophytic vegetation	714	None-low acid neutralizing ability (Glass et al., 1982; Tao & Feng, 2000)	0	n/a
H8310	Caves not open to the public	714	No soil type specified. High sensitivity is assumed.	0	n/a
H9130	Asperulo-Fagetum beech forests	1,429	Characteristics similar to H9110-H9160	38,331	Inland marshes * (Type 1 + Type 2 + Type 4 + Type 5 + Type 6)
H9150	Medio-European limestone beech forests of the Cephalanthero-Fagion	1,429	Characteristics similar to H9110-H9160	38,331	Inland marshes * (Type 1 + Type 2 + Type 4 + Type 5 + Type 6)
H9180	Tilio-Acerion forests of slopes, screes and ravines	1,071	Characteristics similar to H9190	38,331	Inland marshes * (Type 1 + Type 2 + Type 4 + Type 5 + Type 6)

Table 8-6: Costs of activities associated with construction and/or restoration. Data from DLG (2009) and EU handbooks on Management of Natura 2000 Habitats. Values are investment costs and are not annualized. Table 3.10 in Verburg et al. (2016)

Type	Measures	€/ha	remark
Type 1	Soil removal	42772	Price from DLG, multiplied by additional factor
Type 2	water works	2707	Price from DLG
Type 3	clearing and pruning	3030	Price from EU handbook
Type 4	cut trees, trimming	2010	Price from EU handbook (average of 1320-2700€/ha)
Type 5	planting tree saplings	15773	Price from DLG
Type 6	sowing	300	Price from EU handbook (average of 200-400€/ha)
Type 7	nutrient removal by intensive mowing	1700	Price = yearly mowing + for 5 years additional 340 €/ha (1700€), From EU handbook
Type 8	arable to grassland conversion	135	Price from EU handbook
Type 9	clearing overgrown land	1500	Price from EU handbook
Type 10	Sod cutting	3992.5	Price from DLG

Table 8-7: Multiplication factor for type 1 activity defined in table 3.10, to create a CLC3 land cover type. Table 3.11 in Verburg et al. (2016)

CLC3	Factor
water courses	1
water bodies	1.5
inland marshes	0.6
peat bogs	0.8
moors and heath lands	0.6
grasslands (all types)	0.3

V. N REDUCTION COSTS

Table 8-8: Costs per mole N reduction [€ ha^{-1} yr^{-1}], including compatibility of Nature types and Target Nature types (Schouten et al., 2012; Van der Hoek et al., 2008).

Target Nature Type	Nature Type[1]	Nature Type Name	NT-group	Costs per mole N reduction[2] [€ ha^{-1} yr^{-1}]
az-3.1	N08.02	Open duin	dHei	0.05
az-3.2	N08.03	Open duin	Moeras	0.05
az-3.3	N09.01	Voedselrijke graslanden en akkers	Grasland en akker	0.20
az-3.4	N05.01	Moeras	Moeras	0.21
az-3.5	N12.01	Voedselrijke graslanden en akkers	Moeras	0.05

Target Nature Type	Nature Type[1]	Nature Type Name	NT-group	Costs per mole N reduction[2] [€ ha^{-1} yr^{-1}]
az-3.6	N14.01	Vochtige natuurbossen	bos	0.05
az-3.7	N15.01	Droge natuurbossen	bos	0.05
az-3.8	N14.02	Vochtige natuurbossen	Moeras	0.05
az-4.1	N13.01	Vogelgraslanden	Grasland en akker	0.05
du-3.10	N11.01	Droge natuurbossen	Grasland en akker	0.05
du-3.11	N17.01	Cultuurhistorische bossen	bos	0.05
du-3.12	N15.01	Droge natuurbossen	bos	0.05
du-3.13	N15.01	Droge natuurbossen	bos	0.05
du-3.14	N15.01	Droge natuurbossen	Moeras	0.05
du-3.16	N17.03	Cultuurhistorische bossen	Moeras	0.05
du-3.3	N09.01	Kwelders en schorren	Grasland en akker	0.20
du-3.4	N05.02	Open duinen	Moeras	0.30
du-3.5	N10.01	Vochtige schraalgraslanden	Moeras	0.20
du-3.6	N12.01	Voedselrijke graslanden en akkers	Moeras	0.20
du-3.7	N08.02	Open duinen	Grasland en akker	0.20
du-3.8	N08.04	Open duinen	dHei	0.08
du-3.9	N08.03	Open duinen	Moeras	0.20
du-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
du-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05
gg-3.1	N09.01	Kwelders en schorren	Grasland en akker	0.05
gg-3.2	N09.01	Kwelders en schorren	Grasland en akker	0.20
hl-3.10	N14.03	Vochtige natuurbossen	bos	0.05
hl-3.11	N14.01	Vochtige natuurbossen	beek	0.05
hl-3.12	N17.01	Cultuurhistorische bossen	bos	0.05
hl-3.3	N05.02	Moerassen	Moeras	0.30
hl-3.4	N11.01	Droge schraalgraslanden	Grasland en akker	0.20
hl-3.5	N11.01	Droge schraalgraslanden	dHei	0.20
hl-3.6	N12.01	Voedselrijke graslanden en akkers	Moeras	0.20
hl-3.7	N10.01	Vochtige schraalgraslanden	Moeras	0.20
hl-3.8	N14.02	Vochtige natuurbossen	bos	0.05
hl-3.9	N17.02	Cultuurhistorische bossen	bos	0.05
hl-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
hl-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05
hz-3.10	N06.01	Voedselarme venen en vochtige heiden	nHei	0.08
hz-3.11	N07.01	Droge heiden	bos	0.05
hz-3.12	N17.02	Cultuurhistorische bossen	bos	0.05
hz-3.13	N15.01	Droge natuurbossen	bos	0.05
hz-3.14	N14.02	Vochtige natuurbossen	bos	0.05
hz-3.15	N14.01	Vochtige natuurbossen	beek	0.05
hz-3.16	N14.02	Vochtige natuurbossen	bos	0.05
hz-3.17	N17.01	Cultuurhistorische bossen	bos	0.05
hz-3.18	N16.01	Droge natuurbossen	bos	0.05
hz-3.19	N17.03	Droge natuurbossen	bos	0.05
hz-3.3	N12.06	Moerassen	Moeras	0.30
hz-3.4	N06.05	Voedselarme venen en vochtige heiden	nHei	0.20
hz-3.5	N11.01	Droge schraalgraslanden	dHei	0.05

Target Nature Type	Nature Type[1]	Nature Type Name	NT-group	Costs per mole N reduction[2] [€ ha^{-1} yr^{-1}]
hz-3.6	N12.01	Voedselrijke graslanden en akkers	Moeras	0.20
hz-3.7	N10.01	Vochtige schraalgraslanden	Moeras	0.20
hz-3.8	N07.02	Droge heiden	dHei	0.05
hz-3.9	N07.01	Droge heiden	dHei	0.08
hz-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
hz-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05
lv-3.10	N06.03	Vochtige natuurbossen	Moeras	0.05
lv-3.3	N05.02	Moerassen	Moeras	0.17
lv-3.4	N10.01	Vochtige schraalgraslanden	Moeras	0.20
lv-3.5	N12.01	Voedselrijke graslanden en akkers	Moeras	0.20
lv-3.6	N06.04	Voedselarme venen en vochtige heiden	nHei	0.05
lv-3.7	N07.01	Vochtige natuurbossen	Moeras	0.05
lv-3.8	N17.01	Cultuurhistorische bossen	Moeras	0.05
lv-3.9	N14.02	Vochtige natuurbossen	Moeras	0.05
Lv-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
lv-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05
ri-3.10	N14.01	Vochtige natuurbossen	Moeras	0.05
ri-3.11	N17.01	Cultuurhistorische bossen	bos	0.05
ri-3.12	N17.03	Cultuurhistorische bossen	Moeras	0.05
ri-3.3	N05.02	Moerassen	Moeras	0.26
ri-3.4	N10.01	Vochtige schraalgraslanden	Moeras	0.20
ri-3.5	N11.01	Droge schraalgraslanden	Moeras	0.20
ri-3.6	N02.01	Droge schraalgraslanden	bos	0.05
ri-3.7	N15.01	Vochtige natuurbossen	bos	0.05
ri-3.8	N17.02	Cultuurhistorische bossen	Moeras	0.05
ri-3.9	N14.03	Vochtige natuurbossen	bos	0.05
ri-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
ri-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05
zk-3.10	N14.02	Vochtige natuurbossen	Moeras	0.05
zk-3.11	N14.02	Vochtige natuurbossen	Moeras	0.05
zk-3.12	N17.01	Cultuurhistorische bossen	Moeras	0.05
zk-3.13	N17.03	Cultuurhistorische bossen	Moeras	0.05
zk-3.3	N12.04	Voedselrijke graslanden en akkers	Grasland en akker	0.20
zk-3.4	N05.02	Moerassen	Moeras	0.30
zk-3.5	N10.01	Vochtige schraalgraslanden	Moeras	0.20
zk-3.6	N12.01	Voedselrijke graslanden en akkers	Moeras	0.20
zk-3.7	N06.02	Voedselarme venen en vochtige heiden	nHei	0.05
zk-3.8	N14.03	Vochtige natuurbossen	bos	0.05
zk-3.9	N17.02	Cultuurhistorische bossen	Moeras	0.05
zk-4.1	N12.05	Voedselrijke graslanden en akkers	Grasland en akker	0.05
zk-4.2	N13.01	Vogelgraslanden	Grasland en akker	0.05

[1] Conversions made by comparing column 1 with information in Appendix C.I. and PBL (2008).

[2] Costs derived from Schouten et al. (2012) and database LEI (2016).

D. Output tables (results)

I. OUTPUTS SCOPING STEP

All information is derived from the annual environmental reports of the power plants (Eneco, 2015).

1. Lage Weide

Parameter	Situation Lage Weide 6
Sector	Energy (Industry)
System boundaries	Operational Phase
Year	2015
Electricity produced [MWh]	1,062,645
Type of Emissions	NO_X
Coordinates emission source [m]	
X:	133,424
Y:	457,245
Height emission source [m]	64.0
Heat content emissions [MW]	33.2
Emission load	
NO_x [kg yr^{-1}]	365,138
PM_{10} [kg yr^{-1}]	1,743

2. Merwedekanaal

Parameter	Situation Merwedekanaal 12
Sector	Energy (Industry)
System boundaries	Operational Phase
Year	2015
Electricity produced [MWh]	375,574
Type of Emissions	NO_X
Coordinates emission source [m]	
X:	133,890
Y:	457,030
Height emission source [m]	64.0
Heat content emissions [MW]	38.864
Emission load	
NO_x [kg yr^{-1}]	133,046
PM_{10} [kg yr^{-1}]	615

3. Enecogen

Parameter	Emission points Enecogen					
	Gasturbine Unit 10	*Gasturbine Unit 20*	*Auxiliary boiler*	*Backup power Unit 10*	*Backup power Unit 20*	*Waterboiler Station*
System boundaries	Operational Phase					
Type of Emissions	NO_x, NH_3	NO_x, NH_3	NO_x	NO_x	NO_x	NO_x
Year	2015					
Electricity produced [MWh]	2,563,188					
Sector	Energy (Industry)					
Coordinates emission source [m]						
X:	66,018	65,988	66,117	66,047	66,018	66,059
Y:	441,750	441,687	441,749	441,778	441,715	441,812
Height emission source [m]	55.0	55.0	55.0	3.0	3.0	8.0
Heat content emissions [MW]	49.3	49.3	0.134	1.78	1.78	0.045
Emission load						
NO_x [kg yr^{-1}]	116,123.2	126,174.4	491.8	131.3	138.3	144.6
Total NO_x [kg yr^{-1}]	243,203.6					
NH_3 [kg yr^{-1}]	1,040.6	93.4	-	-	-	-
Total NH_3 [kg yr^{-1}]	1,134.0					

4. Bio Golden Raand

Parameter	Situation Bio Golden Raand
Sector	Energy (Industry)
System boundaries	Operational Phase
Year	2015
Electricity produced [MWh]	367,285.96
Type of Emissions	NO_X, NH_3
Coordinates emission source [m]	
X:	261,337
Y:	592,991
Height emission source (m)	80.0 m
Heat content emissions (MW)	13.2 MW
Emission load	
NO_x [kg yr^{-1}]	22,720 kg yr^{-1}
NH_3 [kg yr^{-1}]	1,410 kg yr^{-1}
PM_{10} [kg yr^{-1}]	80 kg yr^{-1}

II. OUTPUT TABLES POWER PLANTS

1. *Lage Weide*

Table 8-9: Output Table for Lage Weide at habitat types where 1) N deposition Lage Weide > 1 mole N ha^{-1} yr^{-1} or > 0.05 mole N ha^{-1} yr^{-1} for designated sites, and 2) BD > CDL.

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
95	*NL2003036*	*Oostelijke Vechtplassen*													
H7140B	U2	1.21	0.11%	1474	1540	1300	1757	714	2.16	3.3					
H7140A	U2	1.07	0.10%	1474	1482	1340	1673	1214	1.22	0.4	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
57	*NL3009017*	*Veluwe*													
H9120	U1	0.49	0.044%	1563	2054	1719	2281	1429	1.44	5881.1	A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H9190	U1	0.47	0.042%	1563	2076	1595	2373	1071	1.94	1779.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H4030	U2	0.46	0.041%	1563	1281	1091	1879	1071	1.20	9944.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H2310	U2	0.45	0.041%	1563	1376	1133	1973	1071	1.28	1651.2	A072	Pernis apivorus	Wespendief	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
	U2										A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus cam-pestris	Duinpieper	VU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H2330	U2	0.44	0.040%	1563	1333	1112	1951	714	1.87	228.6	A224	Capri-mulgus europaeus	Nachtzwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus cam-pestris	Duinpieper	VU	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
H3160	U1	0.43	0.039%	1563	1432	1111	1968	714	2.01	36.3	A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H6230vka	U2	0.43	0.039%	1563	1293	1088	1895	714	1.81	326.5	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H91E0C	U1	0.43	0.039%	1563	2014	1549	2450	1857	1.08	15.8					
H4010A	U2	0.43	0.039%	1563	1301	1169	1813	1214	1.07	106.0	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H3130	U2	0.42	0.038%	1563	1490	1149	2012	571	2.61	5.4	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
											H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
											H1831	Luronium natans	Drijvende water-weegbree	MU	Least Concern
											A072	Pernis apivorus	Wespendief	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
											A229	Alcedo atthis	IJsvogel	F	Vulnerable
H5130	U1	0.41	0.037%	1563	1284	1054	1853	1071	1.20	88.3					
H2320	U1	0.40	0.036%	1563	1189	1035	1778	1071	1.11	97.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H7230	U2	0.37	0.033%	1563	1800	1638	1997	1143	1.57	0.5					
H9190	U1	0.35	0.032%	1563	2076	1595	2373	1071	1.94	1779.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H7110B	U2	0.33	0.030%	1563	1432	1184	1766	786	1.82	4.8	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H7140A	U2	0.25	0.023%	1563	1304	1147	1351	1214	1.07	1.9					
38	*NL2014038*	*Rijntakken*													
H6120	U2	0.29	0.026%	1520	1372	1234	1481	1286	1.07	55.7					
105	*NL3004006*	*Zouweboezem*													
Lg03	n.a.	0.28	0.018%	1909	1879	1465	2259	1786	1.05	123.6	H1134	Rhodeus sericeus amarus	Bittervoorn	MU	Least Concern
											H4056	Anisus vorticulus	Platte schijfhoren	MU	Near Threatened
H6410	U2	0.25	0.016%	1909	1624	1462	1784	1071	1.52	1.8					
103	*NL3000036*	*Nieuwkoopse Plassen & De Haeck*													
H7140B	U2	0.22	0.024%	1305	1272	1148	1547	714	1.78	167.7	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H7140A	U2	0.21	0.022%	1305	1251	1155	1457	1214	1.03	1.2	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened

Habitat Types (HT)		N deposition [mole N ha⁻¹ yr⁻¹]	Respon-sible Share	Background Deposition (BD) [mole N ha⁻¹ yr⁻¹]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha⁻¹ yr⁻¹]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
H4010B	U2	0.21	0.022%	1305	1264	1163	1487	786	1.61	17.4	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H6410	U2	0.20	0.021%	1305	1414	1333	1503	1071	1.32	15.3					
53	*NL9801019*	*Buurserzand & Haaksbergerveen*													
H4010A	U2	0.17	0.020%	1587	1548	1341	1951	1214	1.28	90.5					
H4030	U2	0.16	0.019%	1587	1589	1365	2069	1071	1.48	59.6					
H91E0C	U1	0.15	0.017%	1587	2080	1724	2434	1857	1.12	5.4					
H91D0	U2	0.15	0.017%	1587	2475	1919	2686	1786	1.39	7.4					
H7120ah	U2	0.15	0.017%	1587	1570	1357	1919	500	3.14	315.6					
H5130	U1	0.15	0.017%	1587	1640	1394	1903	1071	1.53	10.7					
H2310	U2	0.15	0.017%	1587	1567	1337	1792	1071	1.46	30.9					
H3130	U2	0.14	0.016%	1587	1574	1336	1872	571	2.76	7.1	H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
H7230	U2	0.13	0.015%	1587	1332	1324	1398	1143	1.17	0.5					
H7110A	U2	0.13	0.015%	1587	1455	1336	1566	500	2.91	2.5					
51	*NL2003029*	*Lonnekermeer*													
H4030	U2	0.16	0.014%	1859	1845	1633	2427	1071	1.72	4.8					
H4010A	U2	0.16	0.014%	1859	1835	1609	2448	1214	1.51	1.2					
H3160	U1	0.15	0.013%	1859	2498	2498	2498	714	3.50	0.5					
H3130	U2	0.15	0.013%	1859	1763	1559	1985	571	3.09	2.1	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
H6410	U2	0.15	0.013%	1859	1989	1589	2312	1071	1.86	1.8					
H7150	U1	0.14	0.012%	1859	1760	1679	1804	1429	1.23	0.5					
H6230vka	U2	0.13	0.012%	1859	1640	1640	1640	714	2.30	0.5					
13	*NL3009001*	*Alde Feanen*													
H7140B	U2	0.13	0.014%	1268	1225	1041	1478	714	1.72	58.2					
H6410	U2	0.12	0.013%	1268	1197	1067	1466	1071	1.12	34.6	A151	Philomachus pugnax	Kemphaan	MU	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
H4010B	U2	0.11	0.012%	1268	1257	1245	1280	786	1.60	0.5	A156	Limosa limosa	Grutto	VU	Vulnerable
6	*NL3009006*	*Duinen Schiermonnikoog*													
ZGH2180-Abe	U1	0.12	0.018%	1230	1520	1055	1800	1071	1.42	63.7					
ZGH2130B	U2	0.11	0.017%	1230	1185	1004	1602	714	1.66	88.2	A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
											A222	Asio flammeus	Velduil	VU	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A081	Circus aerugin-osus	Bruine Kiekendief	F	Least Concern
											H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H2190C	U1	0.11	0.017%	1230	1276	1046	1628	1071	1.19	7.1	A081	Circus aerugin-osus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
H6410	U2	0.10	0.015%	1230	1198	957	1407	1071	1.12	0.5	A275	Saxicola rubetra	Paapje	VU	Least Concern
H2130C	U2	0.09	0.014%	1230	1107	833	1452	714	1.55	10.6	A081	Circus aerugin-osus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Responsible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compensation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Lage Weide*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A275	Saxicola rubetra	Paapje	VU	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
ZGH2190C	U1	0.09	0.014%	1230	1405	955	1893	1071	1.31	1.5	A081	Circus aerugin-osus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
87	*NL9801080*	*Noordhollands Duinreservaat*													
H2190-Aom	U1	0.12	0.020%	1196	1183	862	1574	1000	1.18	50.3					
H2180Abe	U1	0.12	0.020%	1196	1429	1010	1678	1071	1.33	889.5					
H2130B	U2	0.11	0.018%	1196	1070	951	1491	714	1.50	458.4					
H2140B	U1	0.11	0.018%	1196	1072	942	1439	1071	1.00	55.3					
H2150	U1	0.10	0.016%	1196	1249	1055	1513	1071	1.17	30.4					
H2130C	U2	0.10	0.016%	1196	1028	968	1292	714	1.44	7.4					
21	*NL2003028*	*Lieftinghsbroek*													
H9120	U1	0.12	0.013%	1759	1732	1353	1950	1429	1.21	10.7					
H9160A	U2	0.12	0.013%	1759	1934	1868	2029	1429	1.35	1.3					
H6410	U2	0.12	0.013%	1759	1895	1560	1974	1071	1.77	0.5					
H91D0	U2	0.12	0.013%	1759	1911	1911	1974	1786	1.07	0.5					

CS Habitat Type	FV	Favourable	U1	Unfavourable-Inadequate	U2	Unfavourable-Bad	(European Environment Agency, 2014)
CS Species	F	Favourable	MU	Moderately Unfavourable	VU	Very Unfavourable	(Ministry of Economic Affairs, 2015c)
Abbreviations		HT = Habitat Type, BD = Background Deposition, CDL = Critical Deposition Load, CS = Conservation Status, N2K = Natura 2000					

2. *Merwedekanaal*

Table 8-10: Output Table for Merwedekanaal at habitat types where 1) N deposition Lage Weide > 1 mole N ha^{-1} yr^{-1} or > 0.05 mole N ha^{-1} yr^{-1} for designated sites, and 2) BD > CDL.

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
57	*NL3009017*	*Veluwe*													
H9120	U1	0,17	0,015%	1563	2054	1719	2281	1429	1,44	5879,2	A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H9190	U1	0,17	0,015%	1563	2076	1595	2373	1071	1,94	1774,1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H4030	U2	0,17	0,015%	1563	1281	1091	1879	1071	1.20	9944.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H2310	U2	0,16	0,014%	1563	1376	1133	1973	1071	1,28	1649,0	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A255	Anthus cam-pestris	Duinpieper	VU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
											A072	Pernis apivorus	Wespendief	FV	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
ZGH4030	U2	0,16	0,014%	1563	1536	1076	2067	1071	1,43	2,8	A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
H2330	U2	0,16	0,014%	1563	1333	1112	1951	714	1.87	228.6	A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus cam-pestris	Duinpieper	VU	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern

Habitat Types (HT)		N deposition [mole N ha-1 yr-1]	Respon-sible Share	Background Deposition (BD) [mole N ha-1 yr-1]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha-1 yr-1]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
H3160	U1	0,15	0,014%	1563	1432	1111	1968	714	2.01	36.3	A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
ZGH4010A	U2	0,15	0,014%	1563	1934	1803	2068	1214	1,59	1,2	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H91E0C	U1	0,15	0,014%	1563	2014	1549	2450	1857	1,08	15,8					
ZGH2310	U2	0,15	0,014%	1563	1796	1417	2062	1071	1,68	2,2	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus cam-pestris	Duinpieper	VU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
H6230vka	U2	0,15	0,014%	1563	1293	1088	1895	714	1.81	326.5	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H3130	U2	0,15	0,014%	1563	1490	1149	2012	571	2.61	5.4	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
											H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
											H1831	Luronium natans	Drijvende water-weegbree	MU	Least Concern
											A072	Pernis apivorus	Wespendief	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
											A229	Alcedo atthis	IJsvogel	F	Vulnerable
H4010A	U2	0,15	0,014%	1563	1301	1169	1813	1214	1,07	104,8	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H5130	U1	0,15	0,014%	1563	1284	1054	1853	1071	1.20	88.3					
H2320	U1	0,15	0,014%	1563	1189	1035	1778	1071	1.11	97.1	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern

Habitat Types (HT)		N deposition [mole N ha-1 yr-1]	Respon-sible Share	Background Deposition (BD) [mole N ha-1 yr-1]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha-1 yr-1]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H7230	U2	0,13	0,012%	1563	1800	1638	1997	1143	1.57	0.5					
ZGH9190	U1	0,13	0,012%	1563	1989	1548	2369	1071	1,86	5,0	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H7110B	U2	0,12	0,011%	1563	1432	1184	1766	786	1.82	4.8	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H7140A	U2	0,09	0,008%	1563	1304	1147	1351	1214	1.07	1.9					
38	*NL2014038*	*Rijntakken*													
H6120	U2	0,11	0,010%	1520	1372	1234	1481	1286	1.07	55.7					
105	*NL3004006*	*Zouweboezem*													
Lg03	n.a.	0,09	0,006%	1909	1879	1465	2259	1786	1.05	123.6	H1134	Rhodeus sericeus amarus	Bittervoorn	MU	Least Concern
											H4056	Anisus vorticulus	Platte schijfhoren	MU	Near Threatened
H6410	U2	0,08	0,005%	1909	1624	1462	1784	1071	1.52	1.8					
103	*NL3000036*	*Nieuwkoopse Plassen & De Haeck*													
H7140B	U2	0,08	0,009%	1305	1272	1148	1547	714	1.78	167.7	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H7140A	U2	0,07	0,007%	1305	1251	1155	1457	1214	1.03	1.2	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H4010B	U2	0,07	0,007%	1305	1264	1163	1487	786	1.61	17.4	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H6410	U2	0,07	0,007%	1305	1414	1333	1503	1071	1.32	15.3					

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Deposition area [ha]	Species				
HABITAT-CODE	*CS*	*Merwedekanaal*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
53	*NL9801019*	*Buurserzand & Haaksbergerveen*													
H4010A	U2	0,06	0,007%	1587	1548	1341	1951	1214	1.28	90.5					
H4030	U2	0,06	0,007%	1587	1589	1365	2069	1071	1.48	59.6					
H91E0C	U1	0,05	0,006%	1587	2080	1724	2434	1857	1.12	5.4					
H91D0	U2	0,05	0,006%	1587	2475	1919	2686	1786	1.39	7.4					
H7120ah	U2	0,05	0,006%	1587	1570	1357	1919	500	3.14	315.6					
H5130	U1	0,05	0,006%	1587	1640	1394	1903	1071	1.53	10.7					
H2310	U2	0,05	0,006%	1587	1567	1337	1792	1071	1.46	30.9					
H3130	U2	0,05	0,006%	1587	1574	1336	1872	571	2.76	7.1	H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
51	*NL2003029*	*Lonnekermeer*													
H4010A	U2	0,06	0,005%	1859	1835	1609	2448	1214	1.51	1.2					
H4030	U2	0,06	0,005%	1859	1845	1633	2427	1071	1.72	4.8					
H3160	U1	0,06	0,005%	1859	2498	2498	2498	714	3.50	0.5					
H6410	U2	0,05	0,004%	1859	1989	1589	2312	1071	1.86	1.8					
H3130	U2	0,05	0,004%	1859	1763	1559	1985	571	3.09	2.1	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
H7150	U1	0,05	0,004%	1859	1760	1679	1804	1429	1.23	0.5					

CS Habitat Type	FV	Favourable	U1	Unfavourable-Inadequate	U2	Unfavourable-Bad	(European Environment Agency, 2014)
CS Species	F	Favourable	MU	Moderately Unfavourable	VU	Very Unfavourable	(Ministry of Economic Affairs, 2015c)
Abbreviations		HT = Habitat Type, BD = Background Deposition, CDL = Critical Deposition Load, CS = Conservation Status, N2K = Natura 2000					

3. *Enecogen*

Table 8-11: Output Table for Enecogen at habitat types where 1) N deposition Enecogen > 1 mole N ha^{-1} yr^{-1} or > 0.05 mole N ha^{-1} yr^{-1} for designated sites, and 2) BD > CDL.

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
87		*Noordhollands Duinreservaat*													
H2180Abe	U1	0,22	0,04%	1196	1429	1010	1678	1071	1,33	889,5					
H2190Aom	U1	0,21	0,03%	1196	1183	862	1574	1000	1,18	50,3					
H2130B	U2	0,21	0,03%	1196	1070	951	1491	714	1,50	458,4					
H2140B	U1	0,18	0,03%	1196	1072	942	1439	1071	1,00	55,3					
H2130C	U2	0,18	0,03%	1196	1028	968	1292	714	1,44	7,4					
H2150	U1	0,17	0,03%	1196	1249	1055	1513	1071	1,17	30,4					
103		*Nieuwkoopse Plassen & De Haeck*													
H7140B	U2	0,2	0,02%	1305	1272	1148	1547	714	1,78	167,7	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H4010B	U2	0,19	0,02%	1305	1264	1163	1487	786	1,61	17,4	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H7140A	U2	0,19	0,02%	1305	1251	1155	1457	1214	1,03	1,2	H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened
H6410	U2	0,18	0,02%	1305	1414	1333	1503	1071	1,32	15,3					
105		*Zouweboezem*													
Lg03		0,17	0,01%	1909	1879	1465	2259	1786	1,05	123,6	H1134	Rhodeus sericeus amarus	Bittervoorn	MU	Least Concern
											H4056	Anisus vorticulus	Platte schijfhoren	MU	Near Threatened
H6410	U2	0,16	0,01%	1909	1624	1462	1784	1071	1,52	1,8					
57		*Veluwe*													
H9120	U1	0,16	0,01%	1563	2054	1719	2281	1429	1,44	5879,2	A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H9190	U1	0,16	0,01%	1563	2076	1595	2373	1071	1,94	1774,1	A072	Pernis apivorus	Wespendief	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
ZGH4030	U2	0,16	0,01%	1563	1536	1076	2067	1071	1,43	2,8	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H2310	U2	0,16	0,01%	1563	1376	1133	1973	1071	1,28	1649	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus campe-stris	Duinpieper	VU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
ZGH2310	U2	0,16	0,01%	1563	1796	1417	2062	1071	1,68	2,2	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus campe-stris	Duinpieper	VU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
ZGH4010A	U2	0,16	0,01%	1563	1934	1803	2068	1214	1,59	1,2	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
ZGH4010A	U2	0,16	0,01%	1563	1934	1803	2068	1214	1,59	1,2	A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
ZGH4010A	U2	0,16	0,01%	1563	1934	1803	2068	1214	1,59	1,2	A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H4030	U2	0,15	0,01%	1563	1281	1091	1879	1071	1,20	9941,9	A072	Pernis apivorus	Wespendief	F	Least Concern
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha⁻¹ yr⁻¹]	Respon-sible Share	Background Deposition (BD) [mole N ha⁻¹ yr⁻¹]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha⁻¹ yr⁻¹]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H2330	U2	0,15	0,01%	1563	1333	1112	1951	714	1,87	228,6	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A255	Anthus campe-stris	Duinpieper	VU	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
H91E0C	U1	0,15	0,01%	1563	2014	1549	2450	1857	1,08	15,8					
H3130	U2	0,15	0,01%	1563	1490	1149	2012	571	2,61	5,4	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
											H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
											H1831	Luronium natans	Drijvende water-weegbree	MU	Least Concern
											A072	Pernis apivorus	Wespendief	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
											A229	Alcedo atthis	IJsvogel	F	Vulnerable
H2320	U1	0,15	0,01%	1563	1189	1035	1778	1071	1,11	97,1	A072	Pernis apivorus	Wespendief	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A233	Jynx torquilla	Draaihals	VU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H4010A	U2	0,15	0,01%	1563	1301	1169	1813	1214	1,07	104,8	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H3160	U1	0,15	0,01%	1563	1432	1111	1968	714	2,01	36,3	A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H6230vka	U2	0,14	0,01%	1563	1293	1088	1895	714	1,81	326,5	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A246	Lullula arborea	Boom-leeuwerik	F	Least Concern
											A276	Saxicola torquatus	Roodborst-tapuit	F	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H5130	U1	0,14	0,01%	1563	1284	1054	1853	1071	1,20	88,3					
ZGH9190	U1	0,13	0,01%	1563	1989	1548	2369	1071	1,86	5	A072	Pernis apivorus	Wespendief	F	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H7110B	U2	0,12	0,01%	1563	1432	1184	1766	786	1,82	4,8	A224	Capri-mulgus europaeus	Nacht-zwaluw	MU	Least Concern
											A338	Lanius collurio	Grauwe Klauwier	VU	Least Concern
H7230	U2	0,12	0,01%	1563	1800	1638	1997	1143	1,57	0,5					
ZGH9120	U1	0,10	0,01%	1563	1687	1439	1813	1429	1,18	1,9	A236	Dryocopus martius	Zwarte Specht	F	Least Concern
H7140A	U2	0,09	0,01%	1563	1304	1147	1351	1214	1,07	1,9	A072	Pernis apivorus	Wespendief	F	Least Concern
38		*Rijntakken*													
H6120	U2	0,11	0,01%	1520	1372	1234	1481	1286	1,07	55,7					
6		*Duinen Schiermonnikoog*													
ZGH2180A be	U1	0,07	0,01%	1230	1520	1055	1800	1071	1,42	63,7					
ZGH2130B	U2	0,07	0,01%	1230	1185	1004	1602	714	1,66	88,2	A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
											A222	Asio flammeus	Velduil	VU	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A081	Circus aeruginosus	Bruine Kiekendief	F	Least Concern
											H1903	Liparis loeselii	Groenknol-orchis	VU	Near Threatened

Habitat Types (HT)		N deposition [mole N ha⁻¹ yr⁻¹]	Respon-sible Share	Background Deposition (BD) [mole N ha⁻¹ yr⁻¹]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha⁻¹ yr⁻¹]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
H2190C	U1	0,07	0,01%	1230	1276	1046	1628	1071	1,19	7,1	A081	Circus aerug-inosus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
ZGH2190C	U1	0,06	0,01%	1230	1405	955	1893	1071	1,31	1,5	A081	Circus aerug-inosus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
H2130C	U2	0,06	0,01%	1230	1107	833	1452	714	1,55	10,6	A081	Circus aerug-inosus	Bruine Kiekendief	F	Least Concern
											A082	Circus cyaneus	Blauwe Kiekendief	VU	Near Threatened
											A222	Asio flammeus	Velduil	VU	Least Concern
											A275	Saxicola rubetra	Paapje	VU	Least Concern
											A277	Oenanthe oenanthe	Tapuit	VU	Least Concern
H6410	U2	0,06	0,01%	1230	1198	957	1407	1071	1,12	0,5	A275	Saxicola rubetra	Paapje	VU	Least Concern
13		*Alde Feanen*													
H7140B	U2	0,07	0,01%	1268	1225	1041	1478	714	1,72	58,2					
H6410	U2	0,07	0,01%	1268	1197	1067	1466	1071	1,12	34,6	A151	Philomach us pugnax	Kemphaan	MU	Least Concern

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
											A156	Limosa limosa	Grutto	VU	Vulnerable
53		*Buurserzand & Haaksbergerveen*													
H4010A	U2	0,07	0,01%	1587	1548	1341	1951	1214	1,28	90,5					
H4030	U2	0,07	0,01%	1587	1589	1365	2069	1071	1,48	59,6					
H91D0	U2	0,06	0,01%	1587	2475	1919	2686	1786	1,39	7,4					
H7120ah	U2	0,06	0,01%	1587	1570	1357	1919	500	3,14	312,6					
H91E0C	U1	0,06	0,01%	1587	2080	1724	2434	1857	1,12	5,4					
H5130	U1	0,06	0,01%	1587	1640	1394	1903	1071	1,53	10,7					
H2310	U2	0,06	0,01%	1587	1567	1337	1792	1071	1,46	30,9					
H3130	U2	0,06	0,01%	1587	1574	1336	1872	571	2,76	7,1	H1166	Triturus cristatus	Kam-salamander	MU	Least Concern
ZGH7120ah	U2	0,05	0,01%	1587	1580	1466	1701	500	3,16	3					
H7110A	U2	0,05	0,01%	1587	1455	1336	1566	500	2,91	2,5					
H7230	U2	0,05	0,01%	1587	1332	1324	1398	1143	1,17	0,5					
51		*Lonnekermeer*													
H4030	U2	0,06	0,01%	1859	1845	1633	2427	1071	1,72	4,8					
H4010A	U2	0,06	0,01%	1859	1835	1609	2448	1214	1,51	1,2					
H3160	U1	0,06	0,01%	1859	2498	2498	2498	714	3,50	0,5					
H3130	U2	0,06	0,01%	1859	1763	1559	1985	571	3,09	2,1	H1042	Leucor-rhinia pectoralis	Gevlekte witsnuitlibel	VU	Least Concern
H6410	U2	0,06	0,01%	1859	1989	1589	2312	1071	1,86	1,8					
H7150	U1	0,06	0,01%	1859	1760	1679	1804	1429	1,23	0,5					
H6230vka	U2	0,06	0,01%	1859	1640	1640	1640	714	2,30	0,5					
21		*Lieftinghsbroek*													
H9120	U1	0,06	0,01%	1759	1732	1353	1950	1429	1,21	10,7					
H9160A	U2	0,06	0,01%	1759	1934	1868	2029	1429	1,35	1,3					

Habitat Types (HT)		N deposition [mole N ha^{-1} yr^{-1}]	Respon-sible Share	Background Deposition (BD) [mole N ha^{-1} yr^{-1}]				Critical Deposition Load (CDL)	Compen-sation factor	Depositoin area [ha]	Species				
HABITAT-CODE	*CS*	*Enecogen*		*Average N2K-site*	*Average per HT*	*Lower 10%*	*Upper 90%*	*[mole N ha^{-1} yr^{-1}]*	*BD / CDL*		*SPECIES-CODE*	*SPECIES-NAME (Scientific)*	*SPECIES-NAME (Dutch)*	*CS NL*	*CS Red List (IUCN)*
H91D0	U2	0,06	0,01%	1759	1911	1911	1974	1786	1,07	0,5					
H6410	U2	0,06	0,01%	1759	1895	1560	1974	1071	1,77	0,5					

CS Habitat Type: FV Favourable; U1 Unfavourable-Inadequate; U2 Unfavourable-Bad (European Environment Agency, 2014)

CS Species: F Favourable; MU Moderately Unfavourable; VU Very Unfavourable (Ministry of Economic Affairs, 2015c)

Abbreviations: HT = Habitat Type, BD = Background Deposition, CDL = Critical Deposition Load, CS = Conservation Status, N2K = Natura 2000

E. Excel Manual

I. DASHBOARD

The final results are calculated for sites with a deposition higher than 1 mole N ha^{-1} yr^{-1} and for sites with a deposition limit of 0.05 mole N ha^{-1} yr^{-1} that have depositions exceeding 0.05 mole N ha^{-1} yr^{-1}. This is done for the following parameters: number of affected Natura 2000 sites, total affected hectares and hectares for which the company is responsible, number of affected habitat types, number of affected species and finally, the biodiversity offsetting costs of N deposition. To have Excel calculate the result for these parameters, filters need to be applied. Make sure to adjust the formula to the sheet you are referring to. The filters are also indicated in column A on the DASHBOARD sheet. Then for each scenario and parameter separately, copy the value from the left column on the DASHBOARD sheet and 'paste as value' at the right adjacent column.

Parameter	Unit	Filters and formulas	
		1 mole N ha^{-1} yr^{-1}	*0.05 mole N ha^{-1} yr^{-1} (only the sites in Appendix B)*
Natura 2000 sites affected	#	BD>CDL (Column Y) filter "1" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!A4;ROW(LW_2015!A4:A13)-ROW(LW_2015!A4);;1));IF(LW_2015!A4:A13<>"";MATCH("~"&LW_2015!A4:A13;LW_2015!A4:A13&"";0)));ROW(LW_2015!A4:A13)-ROW(LW_2015!A4)+1);1)) CTRL+SHIFT+ENTER	BD>CDL (Column Y) filter "1" PAS Limit (Column X) filter "1" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!A4;ROW(LW_2015!A4:A1367)-ROW(LW_2015!A4);;1));IF(LW_2015!A4:A1367<>"";MATCH("~"&LW_2015!A4:A1367;LW_2015!A4:A1367&"";0)));ROW(LW_2015!A4:A1367)-ROW(LW_2015!A4)+1);1)) CTRL+SHIFT+ENTER
Surface area affected	Ha	BD>CDL (Column Y) filter "1" Habitat code (Column C) filter font "Automatic" =SUBTOTAL(9;LW_2015!K4:K13)	BD>CDL (Column Y) filter "1" Habitatcode (Column C) filter font "Automatic" PAS Limit (Column X) filter "1" =SUBTOTAL(9;LW_2015!J4:J1367)
Surface area affected, for which company is responsible	Ha	BD>CDL (Column Y) filter "1" Habitat code (Column C) filter font "Automatic" =SUBTOTAL(9;LW_2015!AB4:AB13)	BD>CDL (Column Y) filter "1" Habitatcode (Column C) filter font "Automatic" PAS Limit (Column X) filter "1" =SUBTOTAL(9;LW_2015!AA4:AA1369)
Habitat types affected	#	BD>CDL (Column Y) filter "1" Habitat code (Column C) filter font "Automatic" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!C4;ROW(LW_2015!C4:C13)-ROW(LW_2015!C4);;1));IF(LW_2015!C4:C13<>"";MATCH("~"&LW_2015!C4:C13;LW_2015!C4:C13&"";0)));ROW(LW_2015!C4:C13)-ROW(LW_2015!C4)+1);1)) CTRL+SHIFT+ENTER	BD>CDL (Column Y) filter "1" Habitatcode (Column C) filter font "Automatic" PAS Limit (Column X) filter "1" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!C4;ROW(LW_2015!C4:C1367)-ROW(LW_2015!C4);;1));IF(LW_2015!C4:C1367<>"";MATCH("~"&LW_2015!C4:C1367;LW_2015!C4:C1367&"";0)));ROW(LW_2015!C4:C1367)-ROW(LW_2015!C4)+1);1)) CTRL+SHIFT+ENTER
Species affected	#	BD>CDL (Column Y) filter "1" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!R4;ROW(LW_2015!R4:R13)-ROW(LW_2015!R4);;1));IF(LW_2015!R4:R13<>"";MATCH("~"&LW_2015!R4:R13;LW_2015!R4:R13&"";0)));ROW(LW_2015!R4:R13)-ROW(LW_2015!R4)+1);1))	BD>CDL (Column Y) filter "1" PAS Limit (Column X) filter "1" =SUM(IF(FREQUENCY(IF(SUBTOTAL(3;OFFSET(LW_2015!R4;ROW(LW_2015!R4:R1367)-ROW(LW_2015!R4);;1));IF(LW_2015!R4:R1367<>"";MATCH("~"&LW_2015!R4:R1367;LW_2015!R4:R1367&"";0)));ROW(LW_2015!R4:R1367)-ROW(LW_2015!R4)+1);1))

		CTRL+SHIFT+ENTER	*CTRL+SHIFT+ENTER*
Biodiversity offsetting costs of N deposition	€/yr	BD>CDL (Column Y) filter "1" Habitat code (Column C) filter font "Automatic" *=SUBTOTAL(9;LW_2015!AH4:AH1500)*	BD>CDL (Column Y) filter "1" Habitatcode (Column C) filter font "Automatic" PAS Limit (Column X) filter "1" *=SUBTOTAL(9;LW_2015!AG4:AG1500)*

II. OUTPUT TABLE

1. *AERIUS analysis*

1.1 Direct to: https://calculator.aerius.nl/calculator/.

1.2 The following data is input for AERIUS.

a. The emissions that are taken into account, depending on the process characteristics of the power plant this can either be 'NO_x' or 'NO_x and NH_3';
b. The year in which the emissions have taken place;
c. The sector that is causing the emissions, in this case Energy.
d. The (x,y)-coordinates of the emission source (i.e. the chimney);
e. The height of the chimney in m;
f. The heat content in MW;
g. The emission load in kg/year for NO_x, NH_3 and PM_{10}.

This data can be extracted from the electronic environmental reports that industrial parties obliged to deliver on a yearly basis.

1.3 Click 'Calculate' to have AERIUS calculate the nitrogen deposition at Natura 2000 sites as a result of electricity and heat production in the power plant.

1.4 A PDF and a GML-file can be exported from AERIUS by clicking 'Export' and entering the requested information. The files contain information on:

- The Natura 2000 sites where N-deposition takes place due to electricity and heat production in the specific gas and biomass power plants;
- The N-deposition up to 0.05 mole N ha^{-1} yr^{-1} due to electricity and heat production in the specific gas and biomass power plants for the nitrogen sensitive habitat types per Natura 2000 site;
- The surface area of the habitat types where the N-deposition exceeds 1 mole ha^{-1} yr^{-1}.

2. *Import AERIUS output data (PDF) into Excel.*

The fastest way to paste the deposition data from the PDF that AERIUS created is the following:

2.1 Copy the name of the Natura 2000 site from the PDF and paste in Excel in cell B4.

2.2 Per Natura 2000 site, copy all habitat types and the associated deposition values from the PDF

2.3 In the Excel file, select cell C4, then click 'Paste' and choose 'Use Text import Wizard…'. A dialogue box opens.

2.4 Select 'Delimited' and click 'Next >'. Select 'Space' and click 'Next >'. Click 'Finish'. The data is now pasted, one word per cell.

2.5 Make sure all habitat codes are in the same column (column C) and drag all deposition values to the same column on the right.

2.6 The habitat name can be recombined using the formula '=C4&" "&D4&" "&E4&" "&F4&" "&G4&" "&H4…….'. Drag the formula down to repeat this step for all habitat types. Copy the recombined habitat names and choose 'Paste as value' at the destination cell range (column E).

2.7 Select all deposition values and also drag these to the destination cell range (column G)

2.8 Drag down the Natura 2000 site name (cell B4) for the destination cell range.

2.9 Repeat the above for all Natura 2000 areas. The sheet should resemble Figure X.

	A	B	C	D	E	F	G	H	I
1	N-deposition data Lage Weide						CONCATENATE(C4;" ";D4;" ";E4;" '		
2			Natura 2000						Results AERIU
3	SITECODE_	SITENAME	HABITATC ODE_NL	Conserva tion	HABITATN/	CODE_N+H	N- depositio	Relative Share	CDL exceedan
4		Solleveld	H2180C		Duinbossen (binnen(		1,7		
5		Solleveld	Lg12		Zoom, mantel en dro		1,7		
6		Solleveld	H2160		Duindoornstruwelen		1,7		
7		Solleveld	H2130A		Grijze duinen (kalkri		1,61		
8		Solleveld	H2180Ao		Duinbossen (droog),		1,59		
9		Solleveld	H2190B		Vochtige duinvalleie		1,22		
10		Solleveld	H2120		Witte duinen		1,11		
11		Solleveld	H2130B		Grijze duinen (kalkar		0,7		
12		Solleveld	H2180Abe		Duinbossen (droog),		0,64		
13		Solleveld	H2150		Duinheiden met strui		0,63		
14		Voornes D	H2130A		Grijze duinen (kalkri		1,07		
15		Voornes D	H2160		Duindoornstruwelen		0,9		

Figure 8-1: Excel file after importing the PDF data into excel. Column B, C, E and G contain data.

3. *Complete the excel sheet with data from Source Table*

3.1 Column A – SITECODE NL:

Fill in the formula =INDEX(SOURCELIST_BACKGROUND!A:A;MATCH(*destination tab sitename!B4*;SOURCELIST_BACKGROUND!C:C;0)) and drag down. This will complete the table with the Dutch Natura 2000 site codes. Check for any errors (#N/A), most likely the sitename will then be spelled differently in the Source Table. Correct this in the Output Table of the power plant.

3.2 Column D – Conservation Status Habitattype:

- Fill in the formula: =INDEX(SOURCELIST_BACKGROUND!I:I;MATCH(*destination tab habitatcode!C4*;SOURCELIST_BACKGROUND!G:G;0)) and drag down. The conservation statuses of each habitattype will be added to the table. For habitattypes classified as living areas (Lg…) no conservation status is defined so #N/A will appear, this can be ignored.
- Apply conditional formatting to Column D: Click 'Conditional Formatting' and choose 'Manage rules'. Select 'New rule' and choose 'Use a formula to determine which cells to format'. Type '=$D1="FV"' in the field 'Format values where this formula is true'. Click 'Format' to define the format for these values (FV). Under 'Applies to' type the cell range: '=$D:$D' and click 'Apply'. Repeat this for (U1) and (U2).

3.3 Column F – CODE_N+H:

Fill in the formula =A4&C4 and drag down. This will create a unique code for each habitattype per Natura 2000 site.

3.4 Column J – Surface area deposition >0.05 mole N $ha^{-1} yr^{-1}$:

Fill in the formula =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!R:R;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0)));"";INDEX(SOURCELIST_BACKGROUND!R:R;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0))) and drag down. The specific surface areas of all habitat types per Natura 2000 site where the deposition exceeds 0.05 mole N ha^{-1} yr^{-1} are added to the table.

3.5 Column K – Surface area deposition >1 mole N $ha^{-1} yr^{-1}$:

For this step the interactive AERIUS Calculator (step 1) is needed. When the impact area is calculated by the model, click on 'Filter' and choose in the right box the Natura 2000 site where depositions exceed 1 mole N ha^{-1} yr^{-1}. In the left box the separate habitat types can be selected. In the graph, the deposition limit can be dragged towards 1 mole N ha^{-1} yr^{-1} and the figure gives the amount of hectares for the selected habitat type where this is the case. This value has to be copied and pasted in the excel model. Repeat this for all habitat types for which the deposition >1 mole N $ha^{-1} yr^{-1}$.

3.6 Column L – Total BD per N2K:

Fill in the formula =INDEX(SOURCELIST_BACKGROUND!L:L;MATCH(*destination tab sitecode_NL!A4*;SOURCELIST_BACKGROUND!A:A;0)) and drag down. The average background deposition for each Natura 2000 site is filled in.

3.7 Column M – Average BD per habitattype per N2K:

- Fill in the formula =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!M:M;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0)));"";INDEX(SOURCELIST_BACKGROUND!M:M;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0))) and drag down. The average background deposition for each habitat type per Natura 2000 site is filled in.
- Apply conditional formatting to Column M: Click 'Conditional Formatting' and choose 'Manage rules'. Select 'New rule' and choose 'Use a formula to determine which cells to format'. Type '=$M4>$P4' in the field 'Format values where this formula is true'. Click 'Format' to define the format for these values (fill>red>pattern 6.25% grey). Under 'Applies to' type the cell range: '=$M:$M' and click 'Apply'. The cells will now all be formatted this way, but this will change once data is added to column P.
- Apply another form of conditional formatting to Column M: Click 'Conditional Formatting' and choose 'Manage rules'. Select 'New rule' and choose 'Use a formula to determine which cells to format'. Type '=AND($M4>$P4;$R4<>"")' in the field 'Format values where this formula is true'. Click 'Format' to define the format for these values (fill>red>pattern 25% grey). Under 'Applies to' type the cell range: '=$M4:$M5000' and click 'Apply'. None of the cells will be formatted this way, but this will change once data is added to column R.

3.8 Column N – 10% lower boundary for BD per habitattype per N2K:

Fill in the formula =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!N:N;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0)));"";INDEX(SOURCELIST_BACKGROUND!N:N;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0))) and drag down. This gives the lower 10%-boundary for the N deposition per N sensitive habitat type within the Natura 2000 site in mole N ha^{-1} yr^{-1}. In 90% of the cases the background deposition exceeds this value.

3.9 Column O – 90% upper boundary for BD per habitattype per N2K:

Fill in the formula =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!O:O;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0)));"";INDEX(SOURCELIST_BACKGROUND!O:O;MATCH(*destination tab CODE_N+H!F4*;SOURCELIST_BACKGROUND!H:H;0))) and drag down. This gives the upper 90%-boundary for the N deposition per N sensitive habitat type within the Natura 2000 site in mole N ha^{-1} yr^{-1}. In 90% of the cases the background deposition is lower than this value.

3.10 Column P – Critical Deposition Load:

Fill in the formula =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!P:P;MATCH(*destination tab habitatcode!C4*;SOURCELIST_BACKGROUND!G:G;0)));"";INDEX(SOURCELIST_BACKGROUND!P:P;MATCH(*destination tab habitatcode!C4*;SOURCELIST_BACKGROUND!G:G;0))) and drag down. The table is now completed with the critical deposition loads of the specific habitat types.

3.11 Column Q – # species per habitat type per N2K

Fill in the formula =MAX(0;COUNTIF(SOURCELIST_BACKGROUND!H:H;*destination tab CODE_N+H!F4*)-1) and drag down. This will indicate for every Natura 2000 site how many species are dependent upon the different habitat types.

3.12 This step requires the use of Visual Basic (VBA). Since running macro's cannot be made undone, it is recommended to save a copy of the file first.

- Open VBA by pressing ALT+F11. Double click in the window 'Project – VBAProject' on the sheet you are working in. A new window opens. Copy the following code and paste this in the coding window (make sure the' range' indicates the column '# species', in this case Q):

```
Sub QtyExtractor()
    Dim i As Long
    Dim LastRow As Long
    Dim Qty As Long
    With ActiveSheet

        LastRow = .Cells(.Rows.Count, "A").End(xlUp).Row
        For i = LastRow To 8 Step -1
            Qty = .Range("Q" & i)
            If .Range("Q" & i) > 1 Then
                .Rows(i).Copy
                .Rows(i + 1).Resize(Qty - 1).Insert

            End If
        Next i
    End With
End Sub
```

Run the macro by clicking the green arrow in the VBA window (). This can take a while. Extra rows will be created for the habitat types that contain multiple species.

- Now conditional formatting has to be applied to indicate these double rows: Click 'Conditional Formatting' and choose 'Manage rules'. Select 'New rule' and choose 'Use a formula to determine which cells to format'. Type '=$F4=$F3' in the field 'Format values where this formula is true'. Click 'Format' to define the format for these values (font>font color> grey). Under 'Applies to' type the cell range: '=$A4:$Q5000' and click 'Apply'. The double rows in columns A:Q will now color grey.

3.13 Column R – SPECIESCODE

For all habitattypes that have dependent species defined, the corresponding codes have to be filled in. This has to be done manually by using an array formula, and is a time-consuming step. For **each** habitattype that contains species (so column Q > 0), paste the following formula: =INDEX(SOURCELIST_BACKGROUND!H:S;SMALLEST(IF(SOURCELIST_BACKGROUND!H:H=*destination tab CODE_N+H!FXX*;ROW(SOURCELIST_BACKGROUND!H:H));ROW(1:1))+1;12). The cell referring to 'destination tab CODE_N+H!FXX' has to be changed to the corresponding row **every time** and subsequently needs to be fixed by pressing F4 (this will show the $-signs). When the formula is correct, press 'Ctrl+Shift+Enter'. The speciescode will appear. If multiple species occur in the habitattype, the formula can be dragged down accordingly.

Repeat this until the end of the sheet.

3.14 Column S:W

Fill in the formula: =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!U:U;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0)));"";INDEX(SOURCELIST_BACKGROUND!U:U;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0))) and drag down. This will give the scientific name of all species that were identified.

3.15 Column T – SPECIESNAME_NL

Fill in the formula: =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!V:V;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0)));"";INDEX(SOURCELIST_BACKGROUND!V:V;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0))) and drag down. This will give the Dutch name of all species that were identified.

3.16 Column U – Conservation Status Species (NL)

- Fill in the formula: =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!W:W;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0)));"";INDEX(SOURCELIST_BACKGROUND!W:W;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0))) and drag down. The conservation statuses of each species will be added to the table.
- Apply conditional formatting to Column U: Click 'Conditional Formatting' and choose 'Manage rules'. Select 'New rule' and choose 'Use a formula to determine which cells to format'. Type '=$U1="Favourable"' in the field 'Format values where this formula is true'. Click 'Format' to define the format for these values (Favourable). Under 'Applies to' type the cell range: '=$U:$U' and click 'Apply'. Repeat this for (Moderately unfavourable) and (Very unfavourable).

3.17 Column V – Conservation Status Breeding Species (NL)

- Fill in the formula: =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!X:X;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0)));"";INDEX(SOURCELIST_BACKGROUND!X:X;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0))) and drag down. The conservation statuses of all breeding species will be added to the table.
- Apply conditional formatting in the same way as in the previous step. Change U for V.

3.18 Column W – IUCN RedList status

Fill in the formula: =IF(ISNA(INDEX(SOURCELIST_BACKGROUND!Y:Y;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0)));"";INDEX(SOURCELIST_BACKGROUND!Y:Y;MATCH(*destination tab SPECIESCODE!$R4*;SOURCELIST_BACKGROUND!$S:$S;0))) and drag down. The red list statuses of all species will be added to the table.

3.19 Column X – PAS limit >0.05

Fill in the formula: *=INDEX(SOURCELIST_BACKGROUND!J:J;MATCH(destination tab SITECODE_NL!A4;SOURCELIST_BACKGROUND!A:A;0))* and drag down. The value '1' will appear for all the sites where the deposition limit for which a permit is required is 0.05 mole N ha^{-1} yr^{-1} instead of 1 mole N ha^{-1} yr^{-1}.

4. Add final calculations

4.1 Column H – Share Company

Fill in the formula: *=Destination tab deposition!G4*/(INDEX(SOURCELIST_BACKGROUND!K:K;MATCH(*Destination tab SITECODE_NL!A7*;SOURCELIST_BACKGROUND!A:A;0))) and change the settings to percentage (%). Drag down. This gives the relative share of the N deposition by the company to the total deposition at the Natura 2000 site.

4.2 Column I – Compensation factor

Fill in the formula *=M4/P4*, i.e. 'BD per habitattype / CDL' and drag down. This gives the extent to which the critical deposition load is already exceeded by the background deposition.

4.3 Column Y – BD>CDL
Fill in the formula *=IF(M4>P4;1;0)*. For the habitattypes where the background deposition exceeds the critical deposition load, the value ‘1’ will appear.

4.4 Column AA – Area to compensate (>0.05)
Fill in the formula ***=H4*I4*J4***, i.e. share company * exceedance CDL * surface area. Drag down. This gives the area for which the company is responsible to compensate per habitat type for depositions higher than 0.05 mole N ha^{-1} yr^{-1}.

4.5 Column AB – Area to compensate (>1)
Fill in the formula ***=H4*I4*K4***, i.e. share company * exceedance CDL * surface area (>1mole). Drag down. This gives the area for which the company is responsible to compensate per habitat type for depositions higher than 1 mole N ha^{-1} yr^{-1}.

4.6 Column AF – Hidden costs (€/ha/yr)
Fill in the formula *=Annuity_factor * (INDEX(SOURCELIST_BACKGROUND!AI:AI;MATCH(Destination tab CODEN+H!F4;SOURCELIST_BACKGROUND!H:H;0)))*. Drag down. This gives the annual biodiversity offsetting costs of N deposition per hectare.

4.7 Column AG – Hidden costs (€/yr) >0.05
Fill in the formula *=AA4*AF4*. Drag down. This gives the annual biodiversity offsetting costs of N deposition per habitat type for depositions higher than 0.05 mole N ha^{-1} yr^{-1}.

4.8 Column AH – Hidden costs (€/yr) >1
Fill in the formula *=AB4*AF4*. Drag down. This gives the annual biodiversity offsetting costs of N deposition per habitat type for depositions higher than 1 mole N ha^{-1} yr^{-1}.