SUMMARY

1. Introduction

The Netherlands has formulated ambitious objectives for realising the generation of sustainable, renewable energy with wind energy playing a prominent role. In addition to onshore wind energy, concrete objectives have been formulated for offshore wind energy. These objectives have been revised and elaborated in the Energy Agreement for Sustainable Growth (SER, Energy Agreement, 2013). The Offshore Wind Energy Bill has entered into force to this end, which gives the State the option of issuing sites for the development of offshore wind farms.

The Minister of Economic Affairs and Climate Policy (in coordination with the Minister of the Interior and Kingdom Relations) is responsible for issuing sites and, for that purpose, drafts an environmental impact assessment (EIA) for each wind farm site decision. This document relates to the EIA for site V in the Hollandse Kust (noord) Wind Farm Zone. The EIA describes the environmental impact of the construction, operation and decommissioning of wind turbines at that site. There are also considerations to allocate a part of site V for further innovative uses and developments (site VI).

The wind turbines installed in the Hollandse Kust (noord) wind farm zone must be connected to the high-voltage grid. TenneT is responsible for providing this connection. This comprises of a single platform in the Hollandse Kust (noord) wind farm zone, the cables from this platform to and over land, and the connection to the high-voltage grid on land. For the offshore grid, TenneT will carry out a separate procedure including an EIA.

This summary addresses the following:

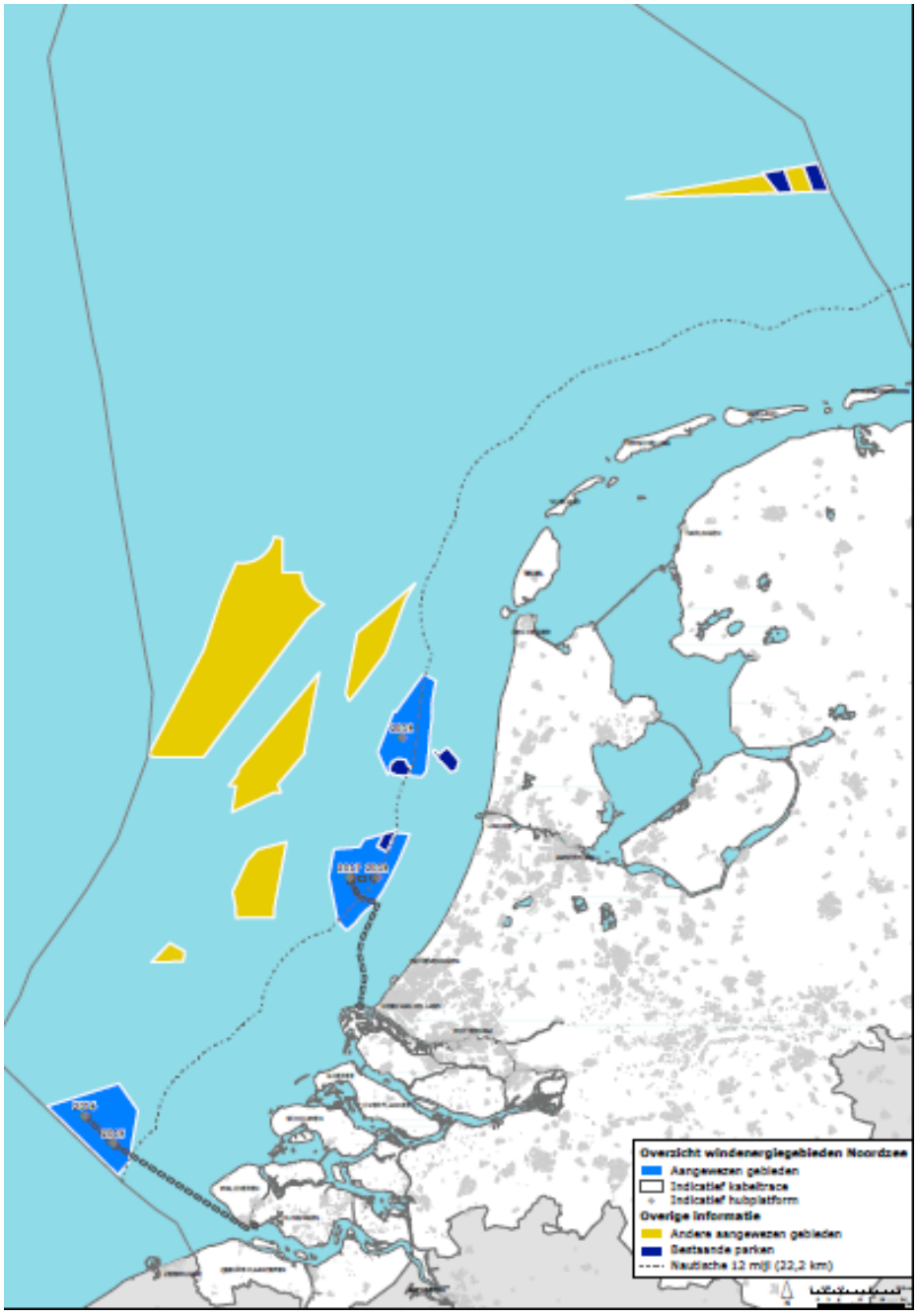
- The policy context and the reason for the site decisions to be taken;
- The choice of location for the the Hollandse Kust (noord) wind farm zone;
- The division of the the Hollandse Kust (noord) wind farm zone;
- The impact assessment method;
- The results of the impact assessment;
- The considerations;
- Any gaps in knowledge and information;
- Monitoring and evaluation.

2. Policy context and cause for wind farm site decisions

Four zones have been designated for the development of offshore wind power generation. See also the following figure:

- Borssele;
- IJmuiden Ver;
- Hollandse Kust;
- Ten Noorden van de Waddeneilanden.

Figure S1 Wind energy zones (blue lined areas).



On 26 September 2014, the Minister of Economic Affairs and Minister of Infrastructure and the Environment sent a letter to the Lower and Upper House presenting the roadmap towards promptly achieving the objective for offshore wind energy to 2023, as agreed in the Energy Agreement (Parliamentary Papers I/II, 2014-15, 33 561, A/no. 11 (reprint)). The letter discusses the offshore grid (previously known as the offshore transmission system), the new system for generating offshore wind power, and the wind farm zones.

The Government concluded that a coordinated grid connection of offshore wind farms leads to less public spending and less impact on the environment. The starting point for the roadmap is that the task of generating offshore wind power can be realised in the most cost-effective manner by means of an offshore grid. This offshore grid is based on standard platforms where a wind power capacity of 700 MW per platform can be connected. Wind turbines within the wind farms can be connected directly to the platforms. On the basis of the Electricity Act 1998, TenneT has been appointed as the offshore grid operator.

The following table shows the timetable for the development of offshore wind power taken from the roadmap. This EIA has been drafted for site V of the Hollandse Kust (noord) wind farm zone.

Year	Timetable (MW)	Roadmap zones
2015[1]	700	*Borssele*
2016	700	*Borssele*
2017	700	*Hollandse Kust (zuid)*
2018	700	*Hollandse Kust (zuid)*
2019	700	*Hollandse Kust (noord)*

The Minister of Economic Affairs and Climate Policy presented on 27 march 2018 the offshore wind energy roadmap 2023 to the Lower House of Parliament (Parliamentary Papers II, 2017/2018, 33 561, nr. 42). This roadmap outlines the development of offshore wind energy from 2024 to 2030 with a capacity of 6.1 GW by utilizing the wind farm zones of Hollandse Kust (west), IJmuiden Ver and Ten Noorden van de Waddeneilanden.

3. Location choice

The National Structural Vision for Offshore Wind Energy further explores the suitability of wind energy in the Hollandse Kust (noord) and the additional wind farm zones between 10 and 12 nautical miles. The effects of wind energy on the Hollandse Kust (noord) wind farm zone are studied in detail in terms of ecology, maritime safety, geology, hydrology, landscape (visibility), economy, tourism, cultural history, archaeology and other uses (oil and gas, fisheries, sand extraction, etc.). It also examines suitability in relation to the other designated wind farm zones (IJmuiden Ver, Hollanddse Kust, Ten Noorden van de Waddeneilanden and Borssele). Further suitability studies, other than the above mentioned, on the Hollandse Kust (noord) wind farm zone for wind energy is therefore not required for this EIA.

4. Division

The surface area of site V, excluding the cable and maintenance zones, is approximately 100 to 120 km^2. From the total surface area of the Hollandse Kust (noord) wind farm zone, 268 km^2 will be designated for the following:

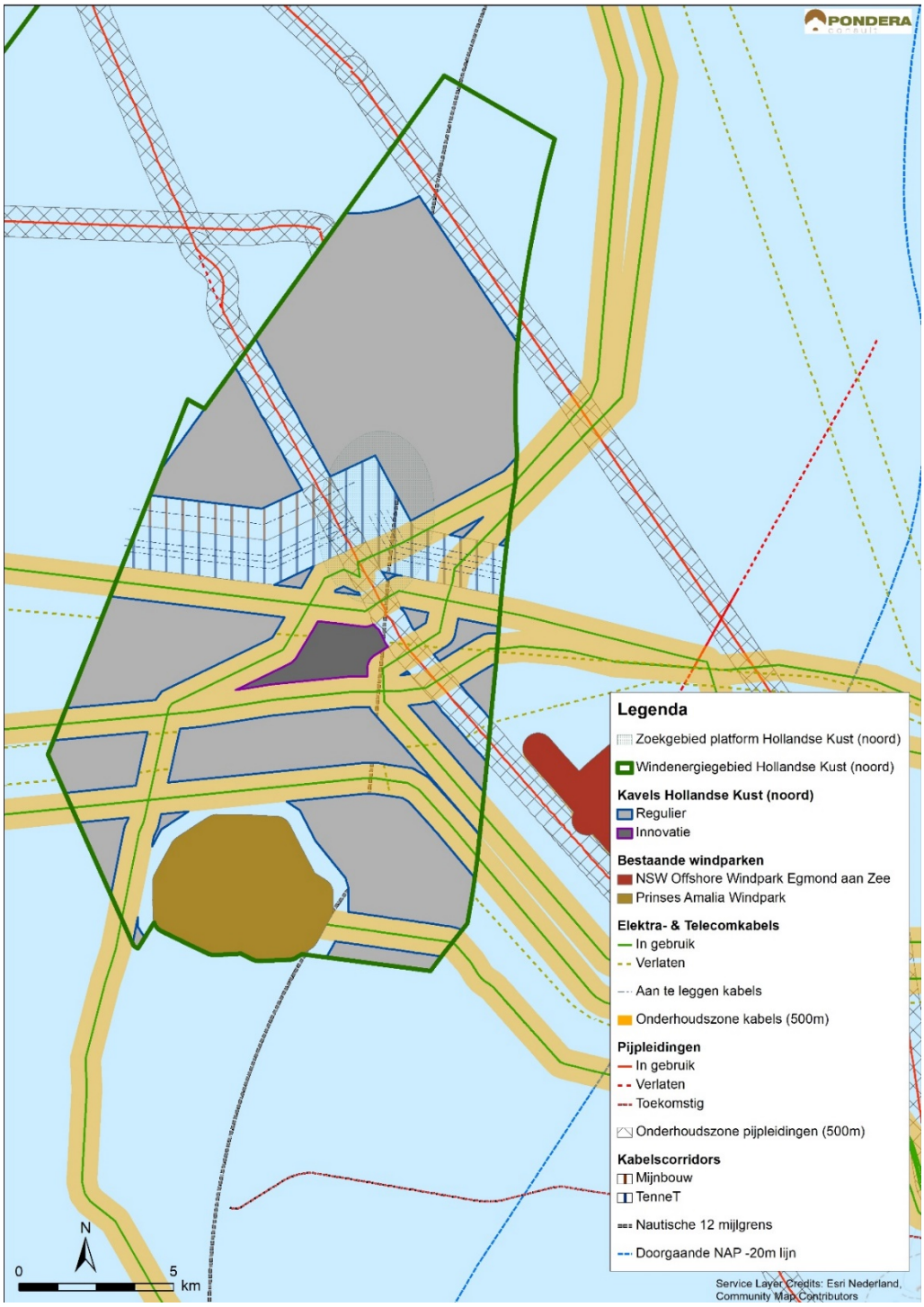
1. Cables and other lines within the wind farm zone. These areas include a 500 metre maintenance buffer zone around the lines;

[1] April 2016

2. TenneT cable platform including a 500 metre designated buffer zone around the platform.
3. Cables from the TenneT platform to land. These areas include a 500 meter safety zone on both sides of each cable. The distance between different cables must be at least 200 metres, so the area must therefore be at least 1,200 metres for the cables from the TenneT platform to land. For an extra future cable route from the TenneT platform to the west, the area should also include enough room. This area must include three cables (two 220 kV and one 66 kV cable) and must therefore be at least 1,400 metres (2x200m +2x500 metres);
4. Area for the current Prinses Amalia Wind Farm;
5. Sufficient areas for safety zones for offshore exploration and mining locations;
6. Area for a cable and its maintenance zone from the TenneT platform to the west. This cable is needed to supply electricity to the offshore exploration and mining platforms.

The boundaries of the Hollandse Kust (noord) wind farm zone are fixed in the wind farm site decision based on Article 9 of the Offshore Wind Energy Bill. Figure S2 presents the boundaries of site V (area “Regulier”). Site VI designated for innovative developments is located within the boundaries of site V and is also shown in Figure S2 (area “Innovatie”).

Figure S2 Proposed division of the Hollandse Kust (noord) wind farm zone



In the letter of 19 May 2015 (Parliamentary Papers II, 2014-15, 33 561, no. 19), the Minister of Economic Affairs indicated that allowing up to 380 MW per site may offer economies of scale and optimal usage of the transmission network, on the understanding however that a maximum connection and transmission capacity is guaranteed for 350 MW per site. These benefits may

result in lower costs per kWh. For those reasons, a total capacity of 760 MW (2 x 380 MW) is assumed for wind farm site V.

5. Impact assessment method

Bandwidth

An EIA assesses alternatives to an activity by examining their effects and comparing them. An alternative is a possible way in which the proposed activity, in this case power generation with wind turbines, can be realised considering the purpose of this activity. In this EIA, alternatives for two areas, each with one wind farm, were examined (two so-called 'wind farm sites'). The alternatives are based on a bandwidth for various wind turbine set-ups and types that are possible within such a wind farm site.

The wind farm site within the Hollandse Kust (noord) wind farm zone is issued with the option for the wind farm developer to develop it at its own discretion. The bandwidth that must be adhered to is recorded in the wind farm site decision.

Bandwidth

By issuing wind farm sites in which various wind turbine set-ups and types and foundation methods are possible, within a certain bandwidth, a flexible design of the wind farm sites is possible. The developer is free to make the wind farm design optimal in terms of cost effectiveness and energy yield. This bandwidth approach makes specific requirements of this EIA. All environmental effects associated with all possible set-ups made possible by the wind farm site decisions should be examined. Researching all possible set-ups is not possible however due to the multitude of potential combinations. Therefore, a worst-case scenario approach is assumed: if the worst-case scenario for potential effects is permissible, then all other set-ups within it are also possible.

Alternatives

The worst-case scenario will differ for different aspects (for example for birds and marine mammals). This is taken into consideration in the study by researching and comparing several worst-case scenarios as alternatives in the EIA. The parameters defined in the worst-case scenario must be named and described, such as the maximum number of turbines, maximum upper and lower limit of the rotor, maximum rotor surface area, characteristics of the foundation method, etc.

To obtain an idea of the possibilities of reducing the effects, mitigating measures are designated and examined for each aspect. This means possibilities for optimisation are identified and prevents solely presenting a worst case scenario.

The bandwidth of design possibilities for the wind farm site to be issued is shown in the following table.

Table S1 EIA bandwidth.

Design	Bandwidth
Capacity of individual wind turbines	Minimum of 8 MW
Highest tip point of individual wind turbines	189 – 251 metres
Lowest tip point of individual wind turbines	25 – 30 metres
Rotor diameter of individual wind turbines	142 – 221 metres
Distance between each wind turbine	At least 4 x rotor diameter
Number of blades per wind turbine	2 – 3
Type of foundations (substructures)	Monopile, jacket, tripile, tripod, gravity-based structure
Type of foundation	Pile foundations, suction buckets, gravity-based structures
Installation method for pile foundations	Vibrohammering, pile driving, drilling, suction
In case of pile-driving foundations: pile-driving energy related to turbine type/pile	1,000 – 3,000 kJ, depending on soil conditions and diameter of foundation
In case of pile-driving foundations, diameter of foundation pile/piles and number of piles per turbine:	
Jacket	4 piles of 1.5 – 3.5 metres
Monopile	1 pile of 8 to 10 metres
Tripod	3 piles of 2 to 4 metres
In case of a foundation without pile driving, dimensions on seabed:	
Gravity-based	Up to 40 x 40 metres
Suction bucket	Bucket diameter: tbd
Electrical infrastructure (inter-array cabling)	66 kV

As indicated, the worst-case scenario for different aspects, for example for birds and marine mammals, can be different. The table below shows the different environmental aspects in the worst-case and best-case scenarios.

Table S2 Worst-case and best-case scenarios within the bandwidth per environmental aspect.

Environmental aspect	Bandwidth	
	Alternative (Worst case)	*Alternative (Best case)*
Birds and bats	95 x 8 MW turbines Lowest tip point 25 m, rotor diameter 142 m	76 x 10 MW turbines Lowest tip point 30 m, rotor diameter 221 m
Underwater life*	76 x 10 MW turbines Pile-driving energy: 3,000 kJ 1 turbine location per day	95 x 8 MW turbines Pile-driving energy: 1,000 kJ 1 turbine location per day
Shipping	95 x 8 MW turbines Jacket foundation with 15 m diameter	76 x 10 MW turbines Monopile foundation with 10 m diameter

Environmental aspect	Bandwidth	
Geology and hydrology	95 x 8 MW turbines	76 x 10 MW turbines
Landscape**	95 x 8 MW turbines Min. rotor diameter 164 m Min. axle height: 107 m	76 x 10 MW turbines Max. rotor diameter 221 m Max. axle height: 140 m
Other use functions	95 x 8 MW turbines	76 x 10 MW turbines
Electricity yield**	95 x 8 MW turbines	76 x 10 MW turbines
* For underwater life, the worst-case and best-case scenario differ per 'sub-aspect' (marine mammals, fish, and benthic life) and can also not be clearly defined in advance. Although the sound production during pile driving at 3,000 kJ is higher than at 1,000 kJ, the number of piles that are driven with greater pile-driving energy is lower, meaning the overall environmental impact may be lower. ** For landscape and electricity yield, there is not really a worst-case or best-case scenario, but the alternatives do specify a bandwidth.		

Assessment

In order to be able to compare the effects of the options per aspect, they are assessed on a +/- scale in relation to the zero option (i.e. the current situation and autonomous development). The following rating scale is used for this purpose, as shown in table S3. The assessment provides a justification for the scoring.

Table S3 Scoring methodology.

Score	Opinion in relation to the reference situation (zero alternative)
--	The intention leads to an extremely noticeable adverse change
-	The intention leads to a noticeable adverse change
0	The intention does not differ from the reference situation
+	The intention leads to a noticeable positive change
++	The intention leads to an extremely noticeable positive change

If the effect is marginal, this is indicated in such cases as 0/+ (marginally positive) or 0/- (marginally negative).

The Appropriate Assessment quantifies the effects in order to evaluate whether the preferred alternative has any significant impact on Natura 2000 areas.

In addition to the effect of a wind farm at wind farm site V, cumulative effects of other wind farms and activities are considered and mitigating measures examined. Furthermore, possible effects related to the innovation site VI are also considered.

6. Result of environmental assessment

The following tables show the assessments of the alternatives per aspect against the various assessment criteria, again without the application of mitigating measures. The tables are then discussed per aspect. This is a summary of the impact assessment, simplifying the description of the assessment criteria.

Birds and bats

Table S4 Assessment of impact on birds and bats without mitigating measures.

Wind farm effect	Alternative 1	Alternative 2
	95 x 8 MW ø 164 m	76 x 10 MW ø 221 m
Construction phase, birds		
- installing foundations	0/-	0/-
- increased shipping	0/-	0/-
Use phase, birds		
Local sea birds		
- collisions	-	-
- barrier effect	0	0
- habitat loss	-	-
- indirect effects	0/-	0/-
Colony birds		
- collisions	-	-
- barrier effect	0	0
- habitat loss	-	-
- indirect effects	0	0
Migratory birds		
- collisions	-	-
- barrier effect	0/-	0/-
- habitat loss	0	0
- indirect effects	0	0
Removal phase, birds		
- installing foundations	0/-	0/-
- increased shipping	0/-	0/-
Bats		
- collisions	--/-	-
- barrier effect	0	0
- habitat loss	0	0
- indirect effects	+/-	+/-
OVERALL ASSESSMENT	--	-

The alternative with 76 x 10 MW turbines and a rotor diameter of 221 metres is the most environmentally friendly alternative for birds and bats, due to the lower number of collision casualties compared to the other alternative. The worst-case scenario is the alternative with 95 x 8 MW turbines and a rotor diameter of 164 metres.

Underwater life

Table S5 Assessment of impact on underwater life without mitigating measures.

Assessment criteria	Impact assessment	Assessment	
		Alternative 1	**Alternative 2**
		95 * 8 MW	76 * 10 MW
Effects of installation, use and removal on: Biodiversity Recruitment Densities/biomass Special species	*Benthic animals* Seabed activities Habitat loss *Fish* Noise/vibration Seabed activities Habitat loss	 0/- 0 0/- 0/- 0	 0/- 0 0/- 0/- 0
Marine mammals Installation Disturbance, barrier effect, habitat loss, change in foraging possibilities due to sound and vibration from installation of foundations Physical harm Use Disturbance due to noise and vibration of turbines Disturbance due to noise and vibration of shipping (maintenance) Removal Disturbance, barrier effect, habitat loss, change in foraging possibilities due to sound and vibration from installation of foundations	 Disturbed surface (km^2) Number of disturbed animals Animal disturbance days Number of affected animals Population effects (North Sea) Disturbed surface (km^2) Number of disturbed animals Disturbed surface (km^2) Number of disturbed animals Disturbed surface (km^2) Number of disturbed animals	 - - -- -- -- 0 0 0 0 0/- 0/-	 - -- -- -- -- 0 0 0 0 0/- 0/-

As regards the impact caused by underwater noise, alternative 1 (95 x 8 MW turbines) seems to be the best case for marine mammals. This is due to the smaller disturbed surface (decreased pile-driving energy), despite having a higher number of foundations compared to alternative 2 (76 x 10 MW turbines). The difference in disturbance surface area is however so minimal that it is not visible in this criterion of the impact assessment (both alternatives score – on this criterion). The effects on porpoises and seals can be very negative if either alternative is applied. The population reduction of porpoises for both alternatives is greater than is considered to be permissible under the Ecology and Cumulation Framework and additional studies (Heinis, 2015). It has been agreed that the population must not fall by more than 5% as a result of the

installation of 10 offshore wind farms under the SER agreement. This is in contrast to the 20% mentioned prior to the agreement. This means that the population decrease calculated for this wind farm must not exceed 510 animals. The effects on seals cannot be quantified using the same method. However, with a maximum disturbance of 98% of the Dutch seal population, a very negative impact cannot be ruled out. The application of mitigating measures means that these effects can be limited, and for porpoises the effects may not exceed this threshold (see table S12 and paragraph 12.5 and 12.6 of the EIA). As regards benthic animals and fish, the effects are extremely minor.

Shipping safety

Table S6 Assessment of impact on shipping and safety without mitigating measures.

Assessment criteria	Impact assessment	Assessment	
		Alternative 1 with 8 MW turbines	**Alternative 2 with 10 MW turbines**
Safety	Risk of collision and propulsion	0/-	0
	Consequential damage of collision and propulsion	0	0
Shipping	Deviation possibilities for vessels crossing	0	0
	Effects of passage of ships below 24 metres	0	0

For two alternatives of site V, the calculations are based on the chances of a turbine collision or propulsion. For the 8 MW turbine variant, the chances are higher than with the 10 MW turbine variant. This is due to the higher number of turbines and the use of jackets in the former variant. The total frequency of collision and propulsion caused by traffic above 24 metres is 0.073882 per year for the alternative with 8 MW turbines, or once every 13.5 years. The total frequency of collision and propulsion caused by traffic above 24 metres is 0.046974 per year for the alternative with 10 MW turbines, or once every 21.3 years. For traffic below 24 metres, the frequency of collision and propulsion is 0.021375 for the 8 MW variant and 0.008895 for the 10 MW variant, or once in every 46.8 and 112.4 years respectively.

As a result of the 8 MW turbine alternative, an oil spill is expected once every 496 years, or once in every 646 years for the 10 MW turbine alternative. The chance of a bunker or cargo oil spill across the whole Dutch Continental Shelf (DCS) increases by 0.40% for the 8 MW turbine alternative as a result of the risk of collision with a wind turbine at site V. This is lower for the 10 MW turbine alternative (0.31%).

The expected average number of deaths as a result of a turbine collision or propulsion for the 8 MW alternative is 1.06×10^{-3}. The expected number of deaths for the 10 MW alternative is 6.6×10^{-4}.

Morphology and hydrology

Table S7 Assessment of impact on geology and hydrology without mitigating measures.

Aspect (during installation, maintenance and operation)	Alternative 1	Alternative 2
	A 8 MW turbine on a suction bucket foundation with a diameter of 17,5 metres. Erosion protection (rock fill): none.	A 10 MW turbine on a gravity-based foundation with a diameter of 40 metres on the seabed. Erosion protection (rock fill): three times the pile diameter.
Waves	0	0
Water movement (water level/current)	0	0
Water depth and soil morphology	0	0
Soil composition	0	0
Turbidity and water quality	0	0
Sediment transport	0	0
Coastal safety	0	0

All morphological and hydrological changes, including other effects resulting from the construction, operation, removal and maintenance of the planned wind farm and cables are highly limited and temporary in nature. The changes, if any, are very low compared to the natural dynamics of the area. Due to the relatively small dimensions of the foundation piles, the relatively large distance between the wind turbines, and the number of wind turbines, any changes are highly localised. The effect is temporary and restricted to the immediate surroundings of the foundation piles and cable route. Both alternatives hardly differ in this respect.

Landscape

Table S8 Assessment of impact on landscape without mitigating measures.

Assessment criteria	Assessment	
	Alternative 1	Alternative 2
	95 x 8 MW turbines Max. tip height 189 m	76 x 10 MW turbines Max. tip height 251 m
- Visibility in percentage of time - Interpretation of visibility on the basis of visualisations	-	-

The visibility of wind turbines at sites V and VI is quantified by the percentage of time that meteorological conditions allow the wind farm to be seen. That is 37% of the daytime during summer months (1 May - 30 September) from the nearest point on land (Castricum aan Zee and Egmond aan Zee). Outside of this period, the visibility percentage is lower. The percentage is also lower at other locations situated farther away from the site.

Furthermore, photo visualisations indicate that the wind farm is visible in good meteorological conditions. The difference between the alternatives is minimal. The 10 MW turbines are separately more visible due to their size, but the number of visible turbines are less than the 8 MW turbine alternative. The 10 MW turbines are still (theoretically) visible at a distance of 47 kilometres or more; the smaller 8 MW turbines are not visible at this distance (due to the horizon effect). In reality this difference is rather small, however.

Based on De Vries et al. (2008) in particular, it has been concluded that the perception is subjective and depends on the background of the observer, such as education, income and attitude towards renewable energy. The largest common denominator from the perception study shows that disruption to the maritime landscape by fixed objects, such as wind farms and oil rigs, is slightly negative, whereby the first disrupting object is deemed to be the most negative and the following objects relatively less and less negative, and that a greater distance results in a less negative perception. Some groups of people also appear to have positive feelings towards offshore wind power and wind turbines in general.

The lighting applied to the nacelle of the wind turbines ensures that the wind farm can be seen from the coast even at night in good meteorological conditions. The more wind turbines there are, the more visible they will be at night. The alternative with the most/greater number of turbines has a greater visibility impact at night than the alternative with the fewest turbines. This effect is reduced if only the turbines in the outer ring of the wind farm are illuminated – see the information circular on offshore wind turbines and offshore wind farms, in relation to aviation (version 3.0, 30 September 2016); see also table S12 containing mitigating measures.

Other use functions

Table S9 Assessment of impact on other use functions without mitigating measures.

Assessment criteria	Impact assessment	Assessment	
		Alt 1 (95 x 8 MW on suction bucket)	Alt 2 (76 x 10 MW on gravity base)
Fishery	Fishery restrictions	0/-	0/-
Oil and gas extraction	Restrictions on oil and gas extraction	-	-
Aviation	Interference with civil aviation	0	0
	Interference with military aviation	0	0
	Interference with Coast Guard	0/-	0/-
	Interference with helicopter traffic	0/-	0/-
Sand, gravel and shell extraction	Restrictions on shallow mineral extraction	-	-
Dredging disposal	Restrictions on dredging disposal dumping areas	0	0
Ship, onshore and aviation radar	Interference with radar	0	0

Assessment criteria	Impact assessment	Assessment	
		Alt 1 (95 x 8 MW on suction bucket)	Alt 2 (76 x 10 MW on gravity base)
Cables and pipelines	Interference with cables and pipelines	0/-	0/-
Telecommunications	Disruption to cable connections	0/-	0/-
	Disruption to ray paths	0/-	0/-
Ammunition dumping areas and military areas	Presence of ammunition dumping areas and military areas	0	0
	Presence of unexploded devices	0	0
Recreation and tourism	Recreational boating restrictions	0	0
	Coastal recreation restrictions	0	0
Cultural history and archaeology	Damage to archaeological remains	0	0
Mussel seed collection installations	Restrictions on mussel seed collection installations	0	0
Existing wind farms	Effect on electricity output of existing wind farms	0/-	0/-

The effects with regard to most of the already existing use functions appear to be very low to non-existent when wind turbines are realized in site V. This is partly because the existing use functions were taken into account in the choice of location. There are minor effects on the use functions of ship and aviation radar, cultural history and archaeology in the form of degradation (archaeology) or influence (ship radar). The effects are rated neutral given the small extent and the alternatives are not distinctive. The effects on dredging disposal are also rated as neutral (0).

The effects on fishing as a whole, given the surface that is lost (approximately 131 km^2) and regarding the value of that area for fishing, are rated slightly negative. In addition, the effects on existing wind farms are also slightly negative, because the wind interception has an adverse effect on the energy yield of the OWEZ and Princess Amalia wind farms as well. The effects on coast guard air traffic and helicopter traffic towards the Q-4C gas platform is also considered to be slightly negative. The effects on ray paths are also slight negative, but can be avoided. Non the less, this score is given because ray paths need to be considered when positioning the wind turbines.

The effects on especially sand extraction are scored as negative due to the existing overlap with active and permitted sand extraction sites and search areas. Oil and gas extraction has also been given a negative score due to Hollandse Kust (noord) wind farm zone being located in permitted extraction as well as exploration zones. Furthermore, (future) seismic studies on the availability of oil or gas fields is nearly impossible while exploiting the wind farm zone. It is important to mention that the effects are slightly more negative with a wind farm of 95 turbines (alternative 1) compared to a wind farm of 76 turbines (alternative 2) due to the spacing

between the turbines. This difference is however not significant in the overall impact assessment.

Electricity yield

Table S10 Assessment of impact on electricity yield without mitigating measures.

Aspects	Assessment	
	Alternative 1	**Alternative 2**
	95 x 8 MW turbines	**76 x 10 MW turbines**
Electricity yield Emissions avoided	++ ++	++ ++

The energy yield for the 76 x 10 MW turbine alternative is approximately 12% higher than the 95 x 8 MW turbine alternative. This does not always have to be the case, but was found for the wind turbines used in this assessment. The Vestas V164-8.0 MW was used in the 8 MW alternative, while the AMSC Sea Titan was used in the 10 MW alternative. The Vestas alternative produced a net annual energy yield of 3,064,800 MWh, while the Sea Titan alternative produced a net annual energy yield of 3,443,000 MWh. The latter energy yield is equivalent to the electricity consumption of approximately 1,043,400 households. This is based on an average yearly household consumption of 3,300 kWh.

The energy yield of the 10 MW alternative is realised with less turbines than the 8 MW alternative, namely 76 versus 95 turbines respectively. The wind farm's contribution in the reduction of CO_2, NO_x, and SO_2 is directly proportional with the net annual energy yield. The reduction is calculated using the average consumption of fuel in electric power plants (mainly gas power plants).

Turbines with a higher installed capacity and larger rotor diameters will most likely produce higher energy yields. The future wind farm developer is free to optimize the wind turbine choice according to their own criteria, including costs and expenditures.

Cumulation

The following table briefly lists the cumulative effects that occur and the consequences they have for the wind farm site decision.

Table S11 Overview of cumulative effects at site V – Hollandse Kust (noord).

Aspect	Relevant cumulative effects	Consequences for wind farm site decision
Birds and bats	Exceeding the PBR in the international worst-case scenario examined with 3 MW turbines in the KEC for the lesser black-backed gull, greater black-backed gull and	If realistic wind turbine types are used in the calculations for the existing and planned wind farms in the southern North Sea (Borssele I/II: 4 MW, Borssele III-V: 6 MW, Hollandse Kust (zuid) I – IV: 6 MW and Hollandse Kust (noord): 8 MW), only the number of lesser black-backed gull casualties would lie above the PBR threshold (within the international scenario) (Gyimesi & Fijn 2015b).If the number of casualties caused by Dutch wind farms against

Aspect	Relevant cumulative effects	Consequences for wind farm site decision
	herring gull cannot be ruled out. In a worst-case scenario in combination with the wind farm developments in the North Sea as considered in the KEC, the provisional PBR value calculated for the Nathusius's pipistrelle would be exceeded.	the Dutch PBR threshold[2] were to be examined, then the cumulative number of casualties would lie at or below the PBR threshold for species of greater gull. Therefore, it can be said with confidence that these populations are resilient enough to withstand the increased mortality rate. Moreover, previous population modelling of the lesser black-backed gull showed that the Dutch population of this species is not at risk (Poot et al. 2011). Mitigating measures could be taken in order to reach acceptable effects (see section 12.5 and 12.6 in the EIA).
Marine mammals	Effects on the FCS cannot be ruled out	Mitigating measures could be taken in order to reach acceptable effects (see section 12.5 and 12.6 in the EIA).
Shipping and safety	Wind farms at the sites in the HKZWFZ and existing wind farms may lead to other effects on shipping and safety.	No consequences for wind farm site decision. The cumulative effect of other wind farms on navigation safety has not been separately detailed but is considered as the basic situation. The distances between the shipping separation regime and future wind farms are determined in the design criteria of distance between shipping routes and wind farms from the North Sea policy documents (2016-2021). Those distances are implemented in the new route structure that entered into force in August 2013.
Morphology and hydrology	Wind farms at other sites in the HKZWFZ may lead to effects on morphology and hydrology.	None. In the implementation of the HKZWFZ (wind farm sites I, II and III), practically the same local, temporary and negligible effects will occur as described for site V. That means that there is no cumulation, not even with other activities and other more distant wind farms.
Landscape	Wind farms at other wind farm sites in the HKZWFZ also affect the visibility of wind turbines from the beach.	Little impact. The development of these wind turbines will increase the intrusion on the horizontal angle of view by wind turbines at site V in the Hollandse Kust (noord) wind farm zone compared to the current situation. The distance to the coast from these wind turbines is generally so great that the meteorological conditions greatly reduce the visibility of the wind turbines. The shortest distance between the offshore wind turbines and the beach is 18.5 kilometres. At this distance, a wind farm in the summer period is visible during the day on average 37% of the time.

Aspect	Relevant cumulative effects	Consequences for wind farm site decision
Other use functions	Wind farms at other wind farm sites in the HKZWFZ and Borssele wind farm zones also affect the other use functions.	Slight effect on fishery. In the further implementation of the Hollandse Kust (noord), the total space used is larger, meaning a larger area is lost for fishing. In total, approximately 1.69% (0.6% Borssele, 0.62% Hollandse Kust (zuid) and 0.47% Hollandse Kust (noord)) of the fishable surface of the DCS is lost, meaning that in cumulation there are limited adverse effects on fishery. Due to the greater number of turbines, it is also more likely that archaeological remains will be harmed. The further implementation of the Hollandse Kust (noord) wind farm zone has limited effects on recreation and tourism because recreational boats are allowed with a length of 24 metres and use a 10 to 20 km wide zone along the coast in particular. Vessels larger than 24 metres that cross the North Sea between the Netherlands and England will need to circumnavigate if wind farm site V and VI are developed. At the southern side of the Hollandse Kust (noord) wind farm zone, is located the operational Prinses Amalia wind farm, which already needs to be circumnavigated. The effects of coastal recreation is considered to be neutral and has further no consequences in the impact assessment. Sand extraction area is reduced due to the realisation o the Hollandse Kust (noord) wind farm zone, with the designated zones of Borssele and Hollandse Kust (zuid) already decreasing the sand extraction area. However, the NWP2 2016-2021 already considered this issue as part of the spatial development of the North Sea.
Electricity yield	Wind farms in the area also cause wind interception (wake-effects), decreasing the wind speeds at other wind farm sites.	None. The degree of wind interception depends on the exact details and wind turbine locations at site V.

Innovation site VI

The wind turbines in site VI will have the same measurement bandwidth and limits as that of site V. Therefore the effects will be no different than that of site V. The designation of site VI as an innovation area has further no special effect on the impact assessment.

Mitigating measures

After assessment, it appears that the conditions in the legal framework can be satisfied for virtually every aspect, although mitigating measures are required to limit the cumulative effects on birds, bats and porpoises. However, the occurrence of other adverse effects due to the construction, operation and removal of the wind farm cannot be excluded. These possible

effects can be mitigated by the following measures. A number of these potential mitigating measures will be selected for the purpose of the preferred alternative.

Table S12 Potential mitigating measures.

Aspect	Effect	Mitigating measure
Birds and bats	Construction and removal phase	• Construction and removal from June to September due to the limited presence of species of sea birds susceptible to disturbance. • Minimising lighting on ships and/or use of a bird-friendly lighting colour. • Reduction of pile-driving or removal noise. However, the effect of the sound of pile driving or removal on birds is unknown and therefore it is not known how necessary this measure is.
	Operational phase	• Installing fewer large turbines instead of more small ones as much as possible. • Installing two-blade instead of three-blade turbines. • Creating a corridor in the wind farm that birds may use. • Casualties can be avoided by smart planning of maintenance when turbines are shut down. • Increasing the chances of birds detecting the wind farm using reflectors, lasers and sound (depending on the species of bird and subject to various restrictions). • Avoiding maintenance works at night and above all during the migration season. • Minimising lighting on ships and/or use of a bird-friendly lighting colour. • Shutting down in certain weather conditions in combination with identified peaks in migration. • Increasing cut-in wind speed (for bats) in the relevant season and at relevant time of day (dusk). • Increasing maximum lowest tip point. • As small as possible wind farm surface (least habitat loss).
Marine mammals	Benthos and fish	• Limiting the size of foundations • Installing foundations that do not need to be pile-driven • Installing 8 MW wind turbines to reduce vibrations
	Disturbance and associated population reduction; PTS.	• Reducing the surface area being disturbed by noise • Limiting the construction period. • Using 'Slow start' and 'Acoustic Deterrent Devices' (ADDs). • Establishing a maximum permissible noise level.

Aspect	Effect	Mitigating measure
Shipping and safety	Propulsion	• Using the Automatic Identification System (AIS). • Deploying an Emergency Towing Vessel.
Morphology and hydrology	-	-
Landscape	Visibility during the day	• Use of colour or camouflage strips on the turbines. • Distribution of information on the what, how and why of the wind farms, so that observers understand why the wind farm is needed. • Selection of as large turbines as possible, so that fewer need to be erected. This also provides a more pleasant landscape. • Limiting the area to be exploited of site V to decrease the number of wind turbines in the angle of view. • Prescribe color RAL7035 (gray) for the turbines.
	Visibility at night	• Constant illumination of the wind turbines (instead of flickering). • With the use of visibility meters, lighting can be dimmed in good visibility conditions, so lights do not always need to turned on. • Using radar to only illuminate wind farm when there is air traffic. • Only illuminate the wind turbines in the outer ring of the wind farm.
Other use functions	Damage to archaeological values	• Changing the location of a wind turbine or cable so as to avoid a possible archaeological object.
	Risk of unexploded devices	• Further investigation is required to locate and remove unexploded devices.
	Effect of wind turbines on shore-based radar system	• Installation of radar on the to be constructed TenneT platforms or between wind farms and shipping routes.
	Site V overlaps with mining permit holders and obstacle free zone around platforms	• Consult with mining companies.
Electricity yield	-	-

7. Considerations

The considerations can be subdivided into the assessment of the legal framework, the choice of the preferred bandwidth, the mitigating measures to be taken, the curtailment of the wind farm site size and the choice of an innovation wind farm site.

Testing against the legal framework

Some mortality amongst birds and fish and a decrease in populations of marine mammals cannot be ruled out in advance. The Offshore Wind Energy Bill integrates the assessment to be carried out under the Nature Conservation Act into the wind farm site decision. By virtue of Article 7 of the Offshore Wind Energy Bill, the competent authority has authority over exemption within the framework of Nature Conservation Act. For the purpose of testing against this Act, an Appropriate Assessment has been carried out. This Appropriate Assessment shows that any significant impact on the conservation objectives of Natura 2000 areas as a result of the preferred alternative can be ruled out.

Other laws and regulations are discussed where relevant in the various aspect chapters and translated into specific standards where necessary. For example, the chapter on underwater life describes the set of standards that is taken as a basis within ASCOBANS and used to determine a measure of acceptable population reduction for porpoises. The planning protection regime for the National Ecological Network, now known as the Nature Network Netherlands (NNN), applies to the whole of the North Sea (EEZ). Paragraph 1.3.1 of annex 5 states how the protection regime for the Nature Network Netherlands (NNN) works in the Dutch North Sea area.

Choice of preferred bandwidth

There are no aspects in this EIA that restrict the bandwidth considered. As a starting point for the bandwidth used, consideration was given in particular to the study into the (cumulative) effects on birds and that has actually led to the minimum caacity per turbine being increased to 8 MW (instead of 3 MW at Borssele wind energy area) The aspect of effects on birds has restricted the bandwidth primarily at the sites in the Borssele wind farm zone. However, mitigating measures on the basis of this EIA must be taken to eliminate or reduce the effects. The measures that must be taken are as follows:

Mitigating measures that must be taken

Measures that are adopted to reduce the effects as required are:

Birds and bats

- During the night (from sunset to sunrise) at times of mass migration, the number of rpm is reduced to less than 1 for each turbine.
- The cut-in wind speed of the turbines is 5.0 m/s at axle height between one hour after sunset and two hours before sunrise from 15 August until 30 September.

Underwater life

- The noise production during pile driving is limited to a maximum value between 165 and 174 dB re μPa^2s at 750 meters from the reed site. This takes into account the differences in

densities of porpoises (as the most sensitive species) in certain seasons and the number of piles that are being driven. The standards determined are provided in the table below.

Table S13 Standards for wind farms in the Hollandse Kust (noord) wind farm zone, including the start-up excess of 1 dB.

Hollandse Kust (noord)	Maximum noise impact (dB re 1 µPa²s over 750 m)*		
760 MW	Period		
# turbines	Jan-May	Jun-Aug	Sept-Dec
95 (assessed here)	165	169	172
84	165	169	173
76 (assessed here)	166	170	174

In addition to the noise standards, ‘Acoustic Deterrent Devices’ and ‘soft start’ procedures to prevent permanent effects on hearing must be used (PTS: *permanent threshold shift*).

Other use functions
Further agreements are needed with stakeholders for the interpretation of the preferred alternative. There are various cables located in the vicinity of and within wind farm site V. For cables and pipelines, a maintenance area of 500 m on both sides is laid down in the wind farm site decision. This is smaller than the 750 metres that is generally applied with telecom cables. The North Sea policy documents (2016-2021) maintain that it is permitted to reduce the maintenance area in order to make efficient use of space in the North Sea.

There is a need for coordination with the mining industry regarding the overlap of site V with mining permits and zones around platforms. There is also a need for coordination with permit holders of sand extraction areas that overlap with site V. The permits for sand extraction will have been withdrawn or expired before the start of construction work. In addition, further research is needed to trace unexploded ordnance and clearing them up. Considerations must also be taken of (possible) archaeological values that may influence the placement of wind turbines in site V. For the purpose of reducing the visibility of the wind farm, the choice is made to prescribe the necessary illumination with constant illuminated lights instead of flickering lights and to prescribe color RAL7035 (gray) for the turbines.

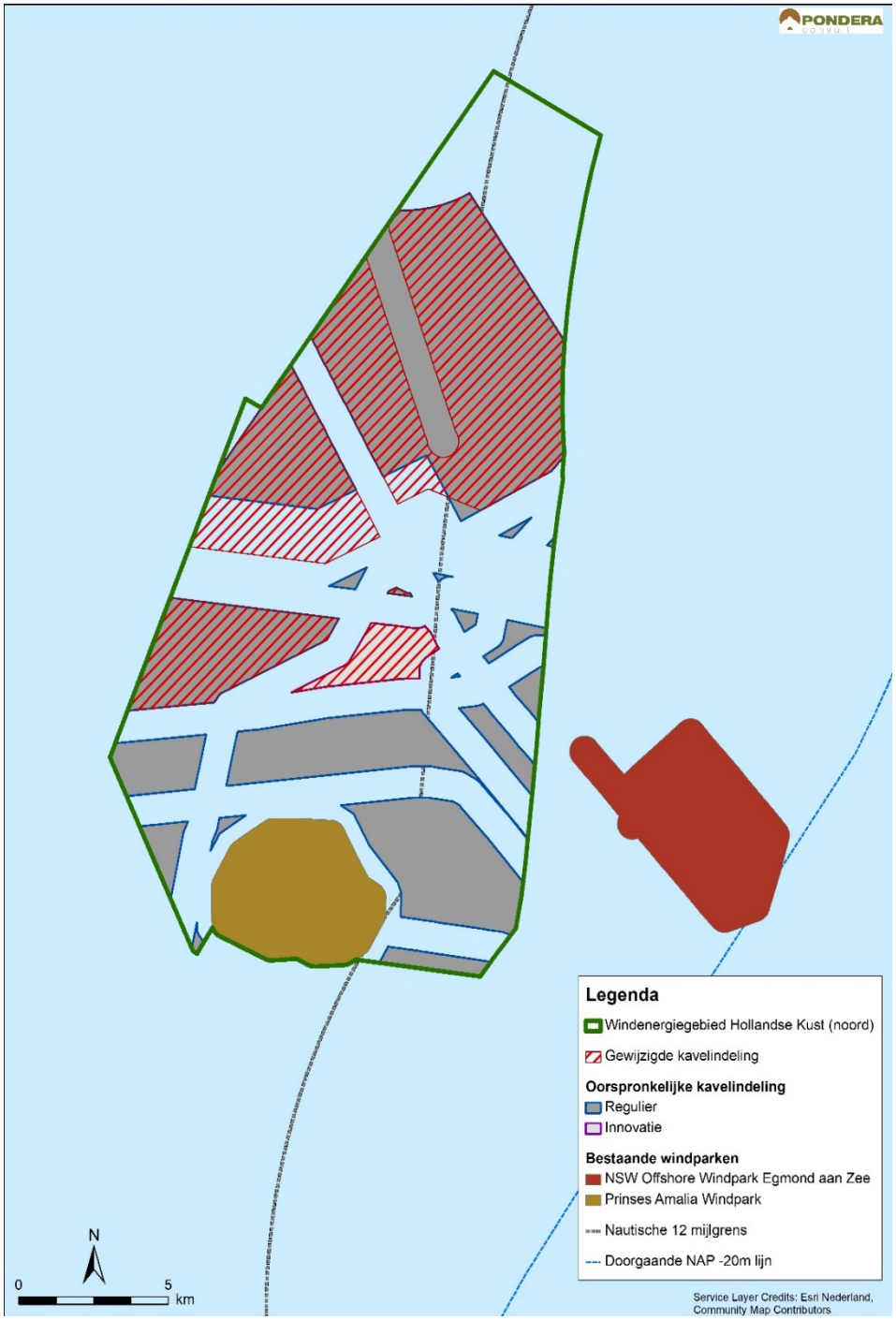
In addition to the measures mentioned, the wind farm site size is limited. The following section gives the reason for this and shows what the effects are.

Size limitations of the wind farm site
The surface of site V available for the placement of wind turbines, which is considered in this EIA, has a size of approximately 131 km^2. Due to the impact of the surface area as investigated in this EIA, research has also been carried out into the effect on the price per kilowatt hour (Levelised Cost of Energy, LCoE) produced in case a smaller surface area is made available. For this purpose, Ecofys carried out research (*in prep.)* which showed that the LCoE remains acceptable if site V has an area of 88 km2 and is classified according to the following figure.

Due to the open location of site V and the large distances to other wind farms like Amalia and OWEZ, a 700 MW wind farm at this site has a roughly equal wake-effect loss as in the wind

farm zones of Borssele (1400 MW including the adjacent Belgian wind farms) and Hollandse Kust (south) (1400 MW including the adjacent Luchterduinen wind farm). Partly because of the reasons for reducing the effects on landscape and fishing, the ministry of Economic Affairs and Climate Policy chooses not to use parts of the wind farm zone for the site.

Figure S3 Adjustments made to the size of wind farm site V



Landscape
In order to limit the effect of visibility, it was decided to use the area in the zone between 10 and 12 nautical miles only to a limited extent. In addition, the Prinses Amalia wind farm will eventually be dismantled and, especially on the south side of the original site V, space will be kept free. This will create a larger gap between site V and the wind farm sites in the Hollandse Kust (south) wind farm zone. This will provide a more limited number of wind turbines on the horizon seen from coastal towns like Noordwijk and Zandvoort.

Fishing
By reducing the wind farm site by 43 km2, less fishing ground is also 'extracted' from the NCP. The effect on fishing is thus reduced.

Other effects
The considerations based on landscape and fisheries have led in particular to the choice of a smaller site V. This EIA has considered a larger area configuration for site V than has now been chosen in the preferred alternative. In general it can be stated that the effects described in this EIA are equal to or less than when the site was restricted as in the preferred alternative. This has to do with the fact that the same setup (95 turbines of 8 MW or fewer turbines of higher capacity than 8 MW each) is provided on a smaller surface area and the number of turbines and the dimensions of the turbines mainly determine the effects and to a lesser extent the exact location of the turbines in the wind farm zone. The only aspect that does not lead to a neutral or positive effect on a smaller site is electricity yield because the wind turbines are placed closer together and thereby increasing the wakes between the turbines. There is still sufficient area because the wind interception is comparable with the sites in the wind farm zones Borssele and Hollandse Kust (south). Appendix 15 describes the impact for each environmental aspect of the confined site of the preferred alternative, in which this conclusion is further substantiated.

No innovation site VI
It has been decided not to designate the separate site VI for innovations. The decision has been made on the basis of the following considerations:

- The number of bids for the tender on an innovation site at Borssele has been very limited.
- The scale disadvantages of separate construction and exploitation of an innovation site raises questions on the efficiency of such a construction.
- The Road Map Wind Energy at Sea 2030 indicates a different focus on the innovation issue. Further elaboration on this requires more time than is currently available, given the planning of the plot decisions for Hollandse Kust (noord).
- With this in mind, it will be investigated whether and, if so, how an innovation site will be developed for future wind farms.

Substantial innovation is also possible within the framework of the regular site. The expectation is that knowledge and expertise around wind farms will develop in the coming years. This concerns the technology of the wind turbines, including for example new turbine types and foundation methods. The site decision therefore does not prevent such innovations if:

- The innovations do not hinder the intended production of an installed capacity of at least 700 MW;

- The innovations comply with the regulations set for the wind farm according to the site decision.

Conclusion on the preferred alternative

The site decision should enable the preferred bandwidth and secure necessary mitigation measures. The site decision will also supervise the confined wind farm site surface area. The preferred bandwidth, mitigating measures and the restricted site size together form the preferred alternative that is guaranteed in the site decision for wind farm site V. No site decision will be taken for site VI.

8. Gaps in knowledge and information

The development of offshore wind farms has a relatively short history. The first monitoring evaluations for previously developed offshore wind farms in England, Denmark, Germany and the Netherlands have since been published. These are the results from relatively short monitoring periods. Certainty about the long-term effects can therefore not yet be given. However, current research and development programmes offer tools for an impact forecast, as presented in this EIA. In investigating and predicting the impact for this EIA, various gaps in knowledge were identified that might limit the understanding of the nature and extent of the impact of a wind farm at site V. There are still some uncertainties surrounding the impact, especially the cumulative effects of multiple wind farms on each other and in combination with other activities in the North Sea.

The gaps in knowledge that exist are not only due to the short history of offshore wind energy; in a broad sense current knowledge about animal species and their densities, diversity and behaviour needs to be supplemented.

In short, the following gaps have been noted:

- Birds: There are gaps in knowledge about collision risks, barrier effects and disruption caused by offshore wind farms (both during the day and at night). In particular, species-specific knowledge is lacking. Validation of models to predict collision bird casualties at sea is lacking. There are also gaps in knowledge about disturbance sensitivities and disturbance distances of seabirds, as well as the extent to which birds can become accustomed to wind farms. Based on literature, it is assumed that 10% of the disturbed birds die. It is not known to what extent this assumption corresponds to reality.
- Bats: knowledge gaps exist with regard to the basic knowledge about population size and species-specific distribution. Unknown is the relative importance of the North Sea for different types of bats and their changes in behaviour as a result of wind farms.
- Benthos: knowledge gaps exist with regard to the ability to predict the consequences of abiotic changes (especially sediment change in the surroundings of the wind farm) on benthos. In addition, the effects of electromagnetic fields along the cables are not yet well known.
- Marine mammals: The main gaps in knowledge related to the consequences on the calculated effects relate to the estimation of effects on the porpoise population. This concerns gaps in knowledge in the area of quantifying the number of disturbed animals and animal disruption days, but also the translation of these to vital rates.

- Fish: specific knowledge gaps with respect to wind farms exist, especially with regard to species and the extent of changes on fish fauna in the longer term as a result of setting restrictions on fishery and the application of hard substrate.
- Shipping: After installing the wind farms, as in previous site decisions, a monitoring obligation is included. It monitors how many and which ships use the wind farm environment and how many and which incidents occur. On the basis of the data that will result from this, it will be decided whether it is desirable to develop an assessment framework and an probability model for this issue.
- Morphology and hydrology: Further research is needed with regard to the possible effects on stratification processes of a large-scale (international) development of wind energy in the North Sea. The actual impact on the stratification processes in the North Sea on developments of the Dutch continental shelf cannot be unambiguously determined.
- Other use functions: Actual economic effects on coastal recreation after the construction of visible wind farms have not been investigated in the Netherlands before. Limited research has been conducted in other countries on this issue. No significant negative effects on recreation and tourism emerged from these previous studies.

The gaps in knowledge do not mean that it is not possible to get a good idea of the effects of a wind farm at wind farm site V in the Hollandse Kust (noord) wind farm zone. A wind farm site decision can be taken despite the existing gaps in knowledge and associated uncertainties. In the decision-making process it is important to understand the uncertainties that played a role in the impact predictions. This understanding is provided by this EIA.

9. Monitoring and evaluation

The Energy Agreement for Sustainable Development (SER agreement, September 2013) contains an agreement to achieve the objectives more quickly and reduce offshore wind power costs by 40% (Parliamentary Papers II, 2012/13, 30 196, no. 202). For these reasons, the Ministry of Economic Affairs and the Ministry of Infrastructure and the Environment decided in 2015 to launch an integral monitoring programme in order to investigate the knowledge gaps with regard to the impact on offshore wind farms in the North Sea ecosystem and to achieve further cost reductions within the ecological boundaries.

A monitoring and evaluation programme called Wozep (*Windenergie op zee ecologisch programma* – offshore wind energy ecological programme) focuses on key environmental issues related to the construction and operation of offshore wind farms. Such issues are predominantly generic rather than specific to individual wind farms.

Both the development of the KEC instrument (update and implementation of knowledge) and the MEP (monitoring and research programme) fall under Wozep. In turn, monitoring and research – in so far as required by the Environmental Management Act – fall under the MEP.

Wozep therefore replaces the monitoring obligation for each wind farm. This results in improved efficiency, which also makes it more cost efficient to achieve the objectives for offshore wind power.

In the Wozep evaluation, attention is paid to the translation of new knowledge in the KEC instrument (this can also mean verifying assumptions and/or impact calculations) on the one hand, and translation into policy and management implications on the other. This is demonstrated by the establishment or modification of mitigating measures. In Wozep, the investigation focuses in particular on those aspects that may increase costs, provide a clear view of them and advise the competent authorities on them. Wozep began in 2016 and will last for five years.

State of affairs Wozep

In the start of 2016, Wozep has set up a number of preparatory activities within the aforementioned themes. These were mainly feasibility studies, opportunities for model-based approaches, preparation of measurement systems and inventories of existing knowledge and data. These studies took into account what is and is being done in the surrounding North Sea countries.

At the end of 2016, a multi-year monitoring and research program was delivered, in which the lines of research for the period 2017-2021 were outlined. Choice of lines of research is determined by considering two time horizons:

- Short term (to 2023): aimed at using the results in the planned wind farms. The importance here is focused on the research into the assumptions made in the ecological assessment related to the wind farms. In addition, the usefulness, necessity and effectiveness of the measures imposed on the wind energy sector to limit ecological damage will also be examined.
- Long-term (after 2023): the knowledge needed to enable further expansion of offshore wind farms in a responsible manner, the expected effects of further expanding the number of wind farms in the North Sea, where can they be located, their possible consequences and how can their negative effects be avoided to a sufficient extent, etc.