Strategies for a Sustainable Development of Offshore Wind Energy: A Review of 10 Years of Research on Offshore Wind Farms in Germany .

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1. Introduction

2. International Review of German Results on Environmental Impacts of Offshore Wind Energy

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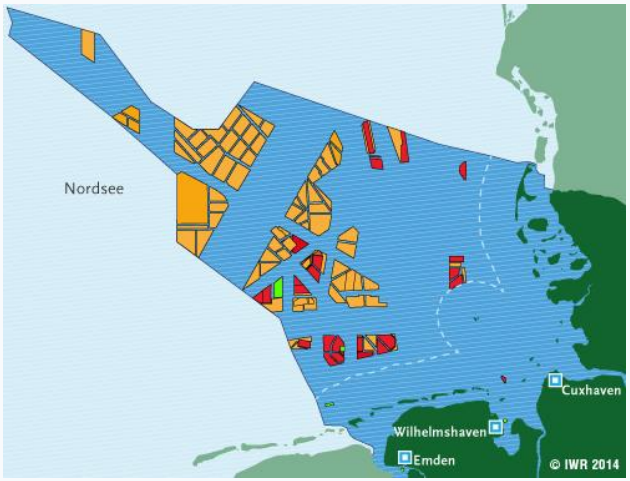
4. Summary

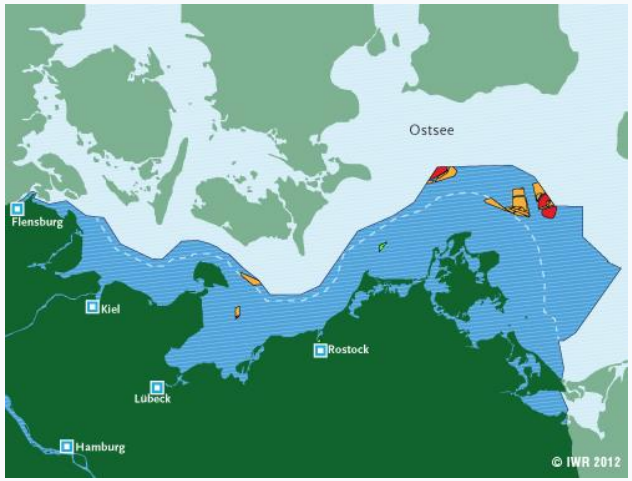
1. Introduction: CV Jens Lüdeke

- Engineer of Landscape Planning (TU Berlin / UPC Barcelona)
- Assessor (Ministry of Environment of NRW)
- Working stations e.g. Federal Agency of Nature Conservation (BfN), Federal Ministry of Environment (BMU), TU Berlin
- Participation in several research projects (e.g. StuK-plus)
- PhD Thesis „Strategies for a Sustainable Development for the Offshore Wind Energy“ (TU Berlin)

1. Introduction: Goals for Offshore Wind in Germany

- Wind energy (onshore and offshore) goal is to produce nearly 50% of Germany‘s electricity demand by 205
- Capacity of Offshore Wind about 3.000 MW (End of 2015)
- 2020: Capacity of offshore wind at least 6.500 MW (-3.500 MW)
- 2030: Capacity of offshore wind at least 15.000 MW (-10.000 MW)



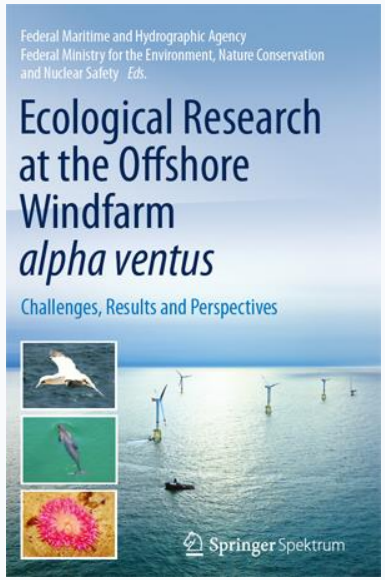


1. Introduction: Environmental Impacts of Offshore Wind

- Knowledge on environmental impacts was limited at the beginning of offshore wind generation in Germany (2002)
- Germany started an offshore test plant (Alpha Ventus)
- Ecological accompanying research and technical innovation for the mitigation of noise emissions was supported with more than 50 Mio. Euros by German Government
- Knowledge of environmental impacts now has increased considerably

1. Methods of Investigation

- Synopsis of the results of published data that were collected in Germany during the past 10 years in connection with Alpha Ventus (RAVE, StukPlus) and the first 13 OWFs in Germany
- International synopsis of state of knowledge (e.g. CWW 2015, results of more than 100 scientific articles)
- to validate the StUK plus results a comparison between German and international results was done (including metastudy by Schuster et al. 2015) →Realisation of the state of knowledge
- Expert interviews: Evaluation of the suggestions for reforms



2. Results on Environmental Impacts on Fish and Benthos: International Review of German Results

- After construction, abundances of fish and crab were higher at wind turbine foundations than in open areas.
- Overall, there was an increase in the number and weight of fish after construction
- StUKplus researchers concluded that OWFs increase abundances of benthos and fish inside OWFs [e.g. Krägefsky S. 2014]
- This conclusion was supported by the international research comparison [Lüdeke 2015].

2. Results on Environmental Impacts on Resting Birds: International Review of German Results

- StUKplus researchers concluded that OWFs can be positive, neutral, or negative for the abundance of seabirds, depending on the species [e.g. Mendel et al 2014].
- This conclusion was supported by the comparison with international research [Lüdeke 2015].
- International data indicated that some species avoided OWFs, some were attracted, and some were unaffected.

2. Results on Environmental Impacts on Migratory Birds: International Review of German Results

- StUKplus researchers concluded that the fatality rate of migratory species offshore could be lower than expected, due to species-specific avoidance behavior [e.g. Hill et al 2014].
- The international comparison in the present study supports a theory of species-specific avoidance behavior [Lüdeke 2015].

2. International Review of German Results

- StUKplus researchers concluded that harbor porpoises leave the area during pile driving (displacement effect) due to the noise, but that this displacement effect was temporary, and there were no long-term impacts on the numbers of porpoises around OWFs [e.g. Gilles et al 2014].
- The comparison with international data confirmed the displacement effect of pile driving and confirmed that it is temporary [Lüdeke 2015].
- International data also showed the abundance of harbor porpoises to be similar (or higher) around operating OWFs than before their construction [Lüdeke 2015].

2. Summary of the Relevant Ecological Effects of OWF

Impacts	Fish	Benthos	Resting Birds	Migrating Birds	Harbor Porpoises (Ramming of OWF)	Harbor Porpoises (Operating OWF)
positive ecological effects	x	x	x (species specific)			(x)
neutral			x (species specific)	x (day)		x
negative ecological effects			x (species specific)	x (night, bad weather)	x	

[Lüdeke 2015]

3. Strategies for a Sustainable Development of Offshore Wind Energy

- Reduce the focus of the Environmental Impact Assessment to relevant impacts with standardized models and thresholds (birds, mammals)
- Apply the latest research findings to reform spatial planning (exclusion of areas of high importance for birds or mammals)
- Apply the latest research to develop technical mitigation measures (e.g. bubble curtains or alternative foundation methods)
- Develop marine compensation measures for the marine impacts by offshore wind (compensation offshore and onshore)

3.1 Reduce the Focus of the EIA to Relevant Impacts in a Standardized Way

- Focus on the decision relevant effects of OWF: birds and harbor porpoises
- Establish standards for Prognosis Models the Environmental Impacts Studies (StUK plus)
- Establish cumulative assessment of effects (international)
- Establish thresholds for the relevant effects

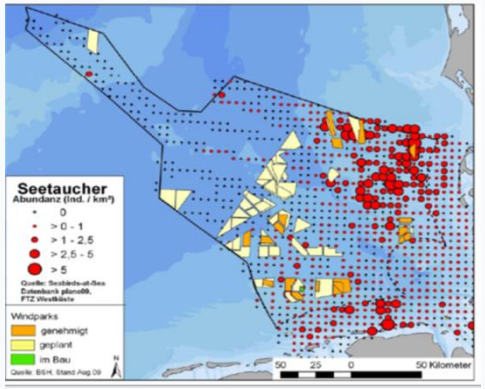
3.1 Reduce the Focus of the EIA to Relevant Impacts in a Standardized Way

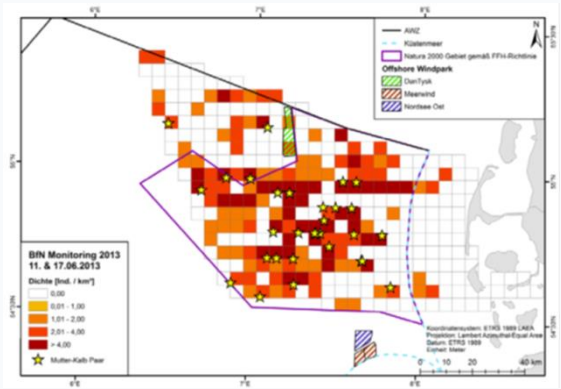
Thresholds for the relevant impacts of OWF in the approval process

Relevant Impact	Threshold
(Temporary) Habitat loss (e.g. mammals, resting birds)	10% of habitat (in sensitive areas 1%) (BMU)
Thresholds of ramming noise in dB SEL	160 dB (re 1 Pa^2s) in a distance of 750 m (UBA)
Additional annual collision of migratory birds	1 % (UNEP)

3.2 Apply the Latest Research Findings to reform Spatial Planning

- Future OWFs should be planned away from important seabird habitats to avoid high rates of collisions and habitat [“Seetaucherhauptrastgebiet”]
- Additionally high-density harbor porpoise habitats should be kept free of future OWFs [see “Schallschutzkonzept” BMU 2014].





3.3 Apply the Latest Research to Develop Technical Mitigation Measures to avoid underwater noise

	Offshore Demonstration	Commercially available	Number of tests (piles) [132]	Mitigation effect ΔSEL [dB] [132]
Big Bubble Curtain	√	√	> 150 (> 300) > 150 (> 300)	Single (BBC) 10 ≤ 13 ≤ 15 Double (DBBC) 14 ≤ 17 ≤ 18)
Small Bubble Curtain	√	-	2	(5 ≤) 10 ≤ 14
Casings/Pile Sleeve	√	√	> 140	10 ≤ 13 ≤ 15
Hydro Sound Damper	√	-	> 50	8 ≤ 10 ≤ 13
Cofferdam	(√)1	(√)[3]	< 10 (> 10)	≥ 20
DBBC + BBC			> 30 (> 70)	15 ≤ 16 ≤ 19
IHC-NMS + BBC			> 90	17 ≤ 19 ≤ 23
BBC (HTL) + HSD			> 10	15 ≤ 16 ≤ 20
DBBC (Weyres)+ HSD			2	14 ≤ 16 ≤ 22

[Bellmann et al 2015]

3.3 Apply the Latest Research to Develop Technical Mitigation Measures to avoid underwater noise

3.4 Application of marine compensation measures

- Federal Nature Conservation Act requires compensation measures for the marine environment in Germany [in 2017 also for OWF]
- Several international agreements (e.g., HELCOM, OSPAR, and Habitat Directive) and the German Marine Spatial Planning document also demand such measures
- Lüdeke, Nagel and Köppel 2014 investigated possible approaches for marine compensation and showed that marine compensatory mitigation measures are a prerequisite for the offshore development

3.4 Application of marine compensation measures

- Compensation measures in the form of monetary payment
- Lesser intensive marine use (to entail fishers and shipping companies being paid not to use specific sensitive areas

Compensation measures onshore:

- Support of affected species (e.g. of the affected birds in the breeding areas or reduce species-specific risks)
- Reduction of risks for harbor porpoises like incidental bycatch, prey depletion or pollution as a compensation for the possible impact of OWFs

3.4 Application of marine compensation measures

- Marine compensation measures for certain marine biotopes and onshore already exist and should be required in the approval procedure.
- Habitat loss for seabirds and for harbor porpoises are of special relevance, the compensation measures for these species (e.g. improvement of the habitats for birds and harbor porpoises by enrichments of food availability like benthos or fish) should be concentrated on
- In cases where compensation was disproportionate to impact, in lieu fees could replace these compensation measures.

3. Steps towards a Strategy for a Sustainable Development of Offshore Wind Energy

Impacts	Fish	Benthos	Resting Birds	Migrating Birds	Harbor Porpoises (Ramming of OWF)	Harbor Porpoises (Operating OWF)
No Measures Necessary	x	x				x
Implementation of a Standard Assessment Method (relevant factor for approval)			x (species specific)	x	x	
Integration of Sensitive Areas into Spatial Planning Necessary			x (species specific)	x	x	
Technical Mitigation Measures Necessary				x (light minimization in the night)	x	
Ecological Compensation Measures Necessary			x (species specific)	x	x	

4. Summary

- Knowledge of the effects of OWFs on the marine environment has been considerably advanced by data gathered in Germany (and internationally) over the past decade
- Sufficient data exists to assess impacts on benthos, fish, birds and mammals.
- Future tasks are to integrate new findings into future planning processes, licensing conditions, and construction processes and to share this knowledge internationally
- The review of the past 10 years of offshore research in Germany and abroad provides strong evidence that sustainable development of offshore wind is possible

A Sustainable Development of Offshore Wind is possible!

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