Due Diligence Services for large scale Off-shore Wind Energy Projects

Dr. Patric Kleineidam
Lahmeyer International, Germany

KWEIA Seminar 2010, COEX Seoul, 15th October 2010

Outline

- Lahmeyer International
- Offshore Wind Market
- Technical Due Diligence of Offshore Wind Farms
- Results and Conclusion

Lahmeyer International

Company:	Lahmeyer International GmbH (LI)	
	Engineering and Consulting Services	
Founding Year:	1966	
Headquarter:	Bad Vilbel, Germany	
Services:	Technical and economic planning and consulting services	
Fields of Activity:	- Energy	
	- Hydropower and Water Resources	
	- Transportation	
LI Group:	7 Associated Companies	
Employees 2010:	LI GmbH / Group :	568 / 1051
Turnover 2009:	LI GmbH / Group :	75.1 / 100 million Euro
Projects:	in 165 Countries	

Overview Consulting Services

LAHMEYER INTERNATIONAL

- Wind Potential Assessment
- Feasibility Studies
- Contractual Services
- Due-Diligence Services
- Market Analysis
- Planning and Design
- Finical & Economic Service
- Construction Supervision
- Operation & Maintenance Services

All our services are tailored to our Clients specific needs.

Key References – Onshore Wind

LAHMEYER INTERNATIONAL

Wind measurements masts installed	**> 230**		
KLIMM country wide wind mappings	**12**	countries	
Wind potential evaluations	**> 220**	wind farms	
KLIMM wind studies	**> 80**	wind farms	
Feasibility studies	**> 80**	wind farms	(> **3,200 MW**)
Due diligence studies	**> 700**	wind farms	(>**14,000 MW**)
Construction supervision	**> 45**	wind farms	(> **1,300 MW**)
Operation and maintenance supervision	**> 85**	wind farms	(> **2,400 MW**)

Key References – Offshore Wind

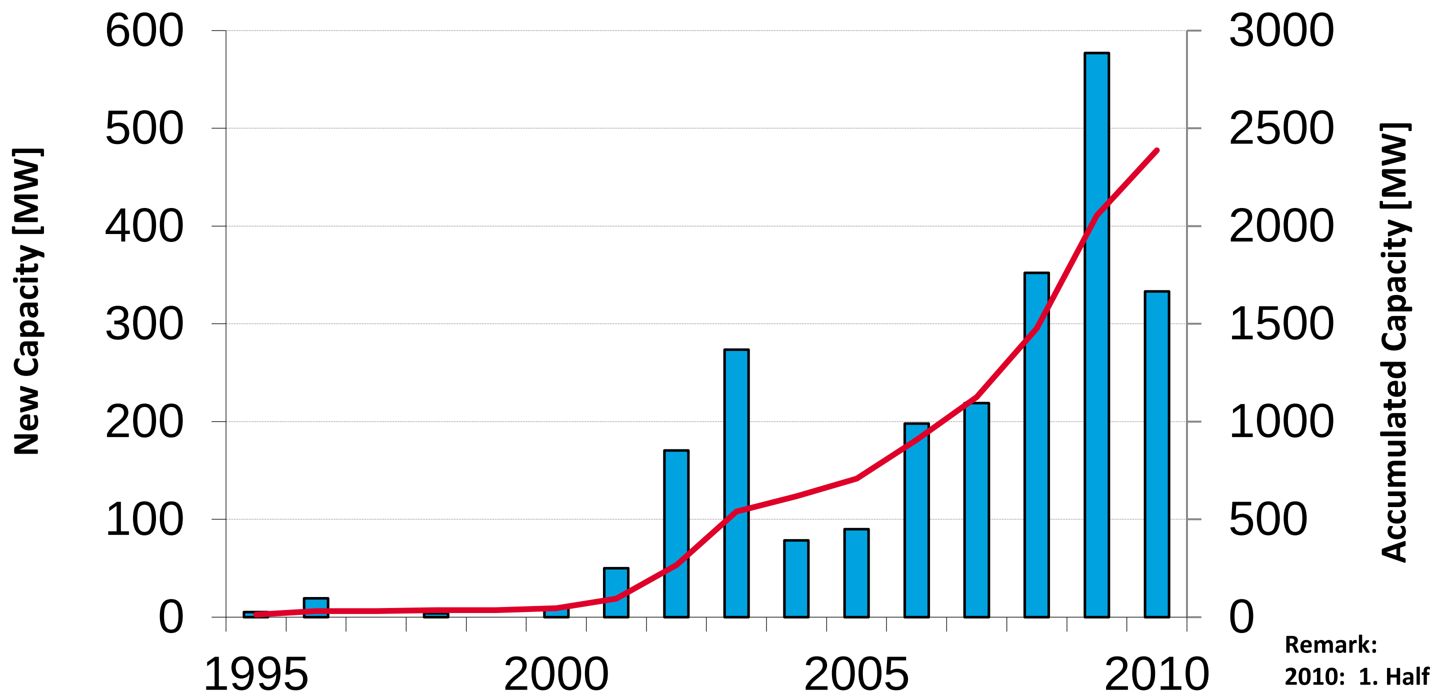
LAHMEYER INTERNATIONAL

▪ Three offshore wind farms, Canada	Pre-Assessment Study
▪ London Array, UK	Co-Development Support
▪ Butendiek Wind Farm, Germany	Development Support
▪ Two Wind Farms, Germany	Wind Studies
▪ Five Wind Farms, Europe	Investors Due Diligence
▪ Adlergrund Wind Farm, Germany	Grid Connection Support
▪ Three Industrial Companies, World	Market Studies
▪ Wind Farm, Germany	Development Support

Offshore Wind Development

LAHMEYER INTERNATIONAL

Offshore is "Picking up the Pace"



- Onshore Wind: approx. 160 GW (end 2009), huge portion in Europe
- Increasing development also in China and North America
- **Korea: Plans for Offshore Wind: > 5 GW**

Offshore Wind in Europe

LAHMEYER INTERNATIONAL

Summary European Offshore Development

- Primarily driven by the UK
- Many projects have been installed in a stop & go process
- Great lack of fit for purpose vessels
- Projects are still in pilot form (Difficult to finally assess risk and cost)

Lessons Learned

- Offshore installation can be done efficiently but never cheaply
- Offshore installation can be done efficiently and sometimes quickly
- Offshore routines should not be deviated from unless new routines are well tried and tested
- Turbine reliability is still a key concern (e.g Multibrid Alpha Ventus)
- Changing project teams kills lessons learned

Development of Market

LAHMEYER INTERNATIONAL

- **Established wind farms in Europe (examples):**

Horns Rev	(DK)	160 MW	turbines: 2 MW	2002
Nysted	(DK)	165.6 MW	turbines: 2.3 MW	2003
Burbo Banks	(UK)	90 MW	turbines: 3.6 MW	2007
Princess Amalia	(NL)	120 MW	turbines: 2 MW	2008
Alpha Ventus	(DE)	60 MW	turbines: 5 MW	2009 (R&D)
Thanet	(UK)	300MW	turbines: 2 MW	2010

- **Wind farms planned or under construction:**

Baltic 1	(DE)	48.3 MW	turbines. 2.3 MW	exp. 2010
BARD Offshore 1	(DE)	400 MW	turbines: 5 MW	exp. 2011
London Array	(UK)	630 MW	turbines: 3.6 MW	exp. 2012
Veja Mate	(DE)	400 MW	turbines: 5 MW	exp. 2011/12
Dan Tysk	(DE)	400 MW	turbines: 5 MW	exp. 2012/13

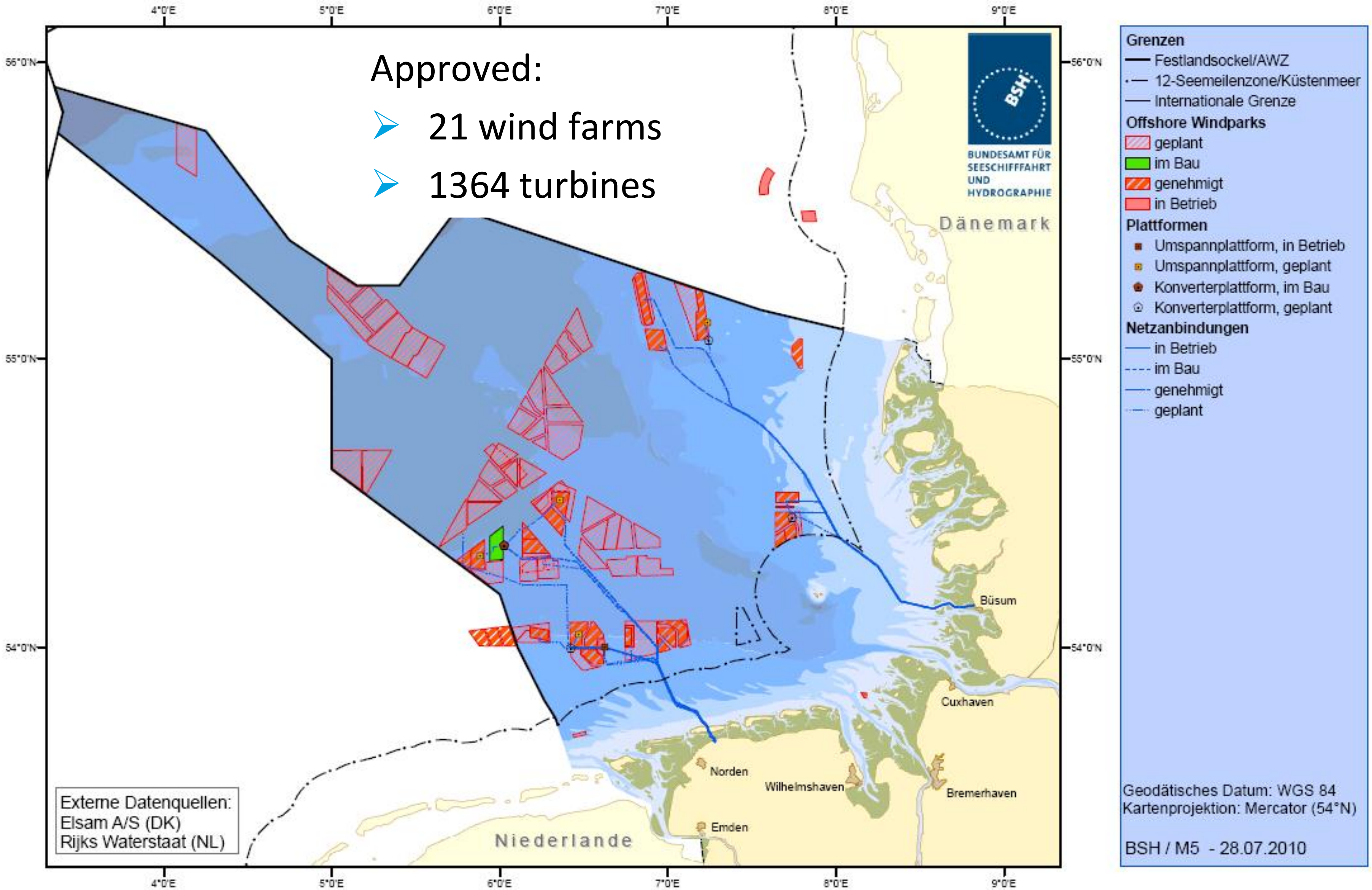
Strong tendency to larger wind farms and larger turbines!

Offshore Wind Farms German North Sea

LAHMEYER INTERNATIONAL

Approved:

- 21 wind farms
- 1364 turbines



http://www.bsh.de/de/Meeresnutzung/Wirtschaft/CONTIS-Informationssystem/index.jsp

Our Offshore Philosophy

Offshore Wind Projects are more than Onshore Technology transferred to the sea.

Offshore Wind Energy Projects are complex energy infrastructure projects, involving multiple project participants, significant investment amounts and can only be successful when carefully planned and professionally executed.

Implications on Financing

LAHMEYER INTERNATIONAL

- Project finance more difficult due to “financial crisis”
- Financing by lending only possible with a deeper level of evaluation (technically, legally and financially)
- Majority of offshore projects is balance-sheet financed, but with growing interest for project finance
- High complexity of Offshore projects is high and technical advisory most cover a number of aspects
- **Independent analysis is elemental for project finance**
- Offshore risks are still new to banks → **independent technical advisor can help to understand them and suggest adequate risk mitigation measures**

Main Goal of Technical Due Diligence

LAHMEYER INTERNATIONAL

- Independent technical project assessment before financial closing
- Identification of technical risks
- Mitigation of risk exposure

Risk assessment

Financial model support | Ass. Contractors & Project Management

Review of Contracts & Permits | Interconnection and transmission concept | Assessment of service strategy

Energy Yield Assessments | Turbine Technology Assessment | Construction Concept & Logistics Review | Foundations / Support structure Review

Technical Due Diligence

Energy Yield Assessment

- Assessment of site conditions
- Review of wind measurements
- Independent review of wind studies:
  - Completeness & plausibility
  - Quality of the applied data base
  - Quality of the methodology
  - Assessment of park layout
- Long term energy yield projections
- Uncertainty analysis
- Long term probability of exceedance levels: P50, P75, PXX

<u>Offshore special attention needs to be paid to:</u>

- Turbine spacing and calculation of wake effects
- Availability & accessibility assumptions
- Loss assumptions

Turbine Technology Assessment

LAHMEYER INTERNATIONAL

- International turbine type approval
- Site suitability class & sub-class analysis
- Offshore suitability / design aspects
- Review of known operational issues
- Grid suitability
- Technical turbine specifications
- Electrical turbine performance
- Certification of power curve
- Reference list, track record

Offshore special attention needs to be paid to:

- Proven and reliable technology
- Service friendliness (access, remote diagnostics, CMS)
- Redundancy in design

Construction & Logistics Review

LAHMEYER INTERNATIONAL

- Review of transport and installation equipment
  - Operating limitations
  - Suitability for the project conditions
- Review of installation / logistics concept
  - General sequence and strategy
  - Staging of equipment or just in time delivery
  - Timing and schedule
  - Interfaces
- Transport route and harbor assessment

- Construction is significantly more complex offshore than onshore, involving more parties and interfaces.
- Small issues can cause significant delays and cost increases.
- Understanding the logistics and construction plan is key to delivering a project on time and within budget.

Contracts and Permits Review

- Large offshore wind parks are currently generally implemented as multi-contract projects
- Multiple contracts need to be reviewed:
  Turbine supply agreement, Foundation,
  Cable, Sub-Station, Installation & Vessels
- Interconnection agreements
- Power purchase agreement and/or other off-take agreements
- Review of Permits: Completeness, Technical constraints
- Review of the Environmental Impact Assessment

Relationship between the individual contracts in terms of schedule, dependency, responsibilities, interfaces!

Implications of restrictions: e.g. time for piling work

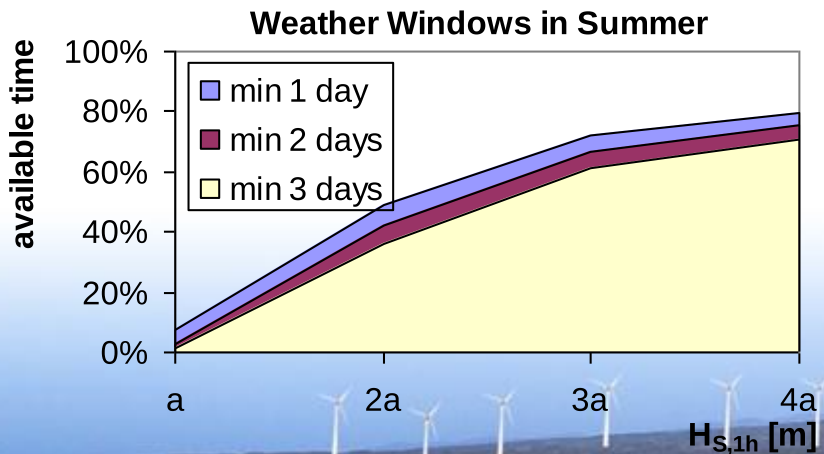
Assessment of Service Strategy

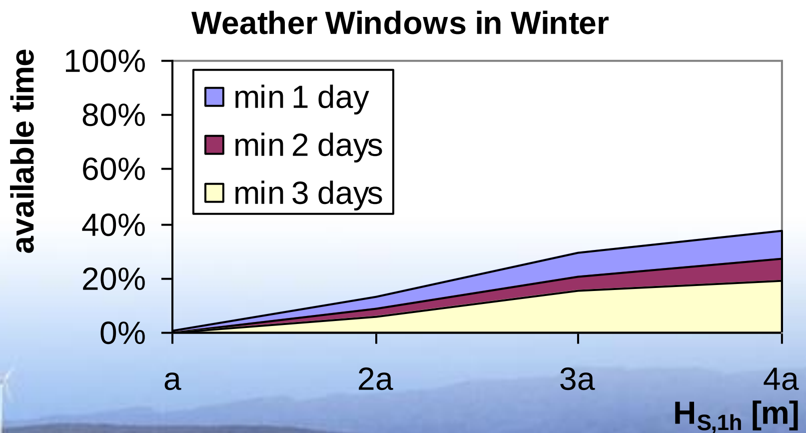
- Review of service contract regarding: availability definition & levels, liquidated damages & bonus payments schemes, warranty terms, reporting system, Service team response times
- Not only WTG, but foundations and sub-station need regular service
- Independent inspections (regular, end-of warranty
- Operation and management strategy review:
  - Harbor base and permanent crew concept
  - Spare part supply / storage concept
  - Vessel strategy (rent or buy)

- Full service concepts are recommended
- Weather & access risk need to be addressed properly
- Lower availability guarantees than onshore are common

OWPAM – Model (1/2)

- In-house “**O**ffshore **W**ind **P**ark **A**vailability and **M**aintenance” - Model
- Model takes into account :
  - Site specific metocean condition (wind speeds and wave heights)
  - Distance to the harbor
  - O & M Strategy (Crews, Vessels, etc.)
  - Wind Park specifics (number of turbines, capacity, etc.)
- Analysis of meteorological conditions using flexible queries to identify for example:
  - Probability of workable weather windows
  - Distribution of wind/wave directions





OWPAM – Model (2/2)

LAHMEYER INTERNATIONAL

- OWPAM – Model can be used to analyze :
  - Inaccessibility of the turbines due to weather (weather downtime)
  - Downtime due to crew unavailability
  - Make availability predictions based on Monte Carlo Simulation of random WTG failures

- OWPAM – Model can be used to optimize:
  - Crew strategy (number of, shift times, etc.)
  - Crew transport strategy (helicopter, Monohull, SWATH, Catamaran)
  - Vessel strategy optimization (buy or rent)
  - Spare part strategy
  - etc.

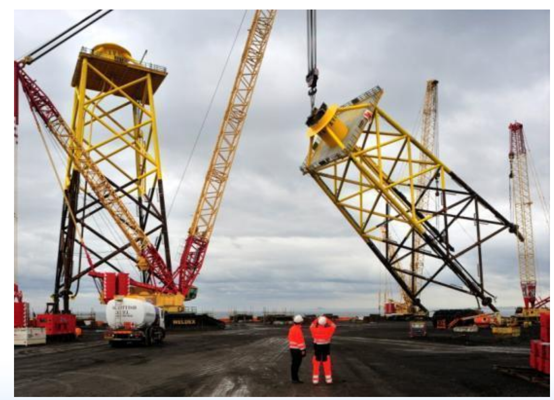
Foundations / Support Structure Review

- Soil investigations & geological reports
- Geophysical and geotechnical reports
- Type and Suitability of foundation / support structure
- Foundation design, drawings & load calculations

- Integrative Design including wind & wave loads on turbine and support structure
- Environmental friendly installation methods
- Learning from design issues, e.g. grouted joints

Monopile

Tripod



Jacket

Foundations Design Alternatives: Pros and Cons

LAHMEYER INTERNATIONAL

	Pros	Cons
Monopile	• Simple structure • Simple construction and installation • Proven technology • Max . Depth finally depends on turbine size	• High exposure to steel prices • Grout design issue • Scour protection generally necessary • Transition piece needs to be installed offshore • Pile driving noise emissions
Gravity Based	• Good for shallow waters • Concrete prices are more stable • Maintenance friendly • No separate transition pieces installed offshore	• Heavy structure • Heavy lifting for transport and installation for deep waters • Long production time • scour protection might be costly • Alignment has to monitored
Tripod	• Solution for deep waters • Piles are smaller • No separate transition pieces installed offshore	• High exposure to steel prices • Heavy structure • Complex welding structure • Heavy lifting for transport and installation • Requires specialized steel fabrication
Jacket	• Solution for deep waters • Lightweight and small piles • No separate transition pieces installed offshore	• Higher exposure to steel prices • Complex construction and installation

Results of the Due Diligence

LAHMEYER INTERNATIONAL

- Identification of risks
- Qualification of risks for anticipation by banks
- Suggestion of mitigation measures

Category A: Severe Obstacles

- These obstacles have to be solved before financial close because they can harm severely the project success or can lead to major contractual claims.

Category B: Major Issues

- Solutions for these issues can technically be achieved in a reasonable period of time and are indispensable conditions for the first disbursement of the loan in order to minimize the lenders risk.

Category C: Improvements

- These improvements are necessary to achieve a transparent, controlled and cost effective construction process.

Conclusions

LAHMEYER INTERNATIONAL

- “Tech. Due Diligence” is part of preparation of project financing
- Independent verification of technical parameters of project financial model
- Technical risks to be identified and assessed in categories
- Mitigation measures suggested
- **Facilitate project realization**

LAHMEYER INTERNATIONAL

Thank you very much for your attention!

Dr.- Ing. Patric Kleineidam
Head of Department Wind Energy
Lahmeyer International, Germany
Tel: +49 (0) 6101 – 55 – 1645
Email : Patric.Kleineidam@lahmeyer.de
www.lahmeyer.de