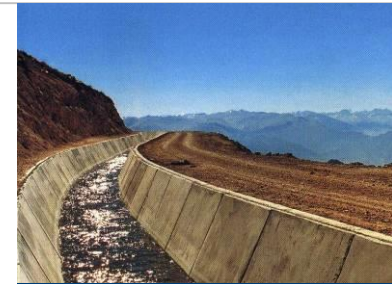


Kostenentwicklung der Offshore Windindustrie im Europäischen Vergleich



WATER SUPPLY



WASTEWATER DISPOSAL








TRANSPORTATION



CONSULTANCY

FICHTNER Water & Transportation: Leistungen

Innerhalb der FICHTNER Gruppe ist FICHTNER Water & Transportation das Zentrum für OFFSHORE WIND

Water Supply & Sanitation	Hydraulic Engineering	Transportation and Traffic Engineering	Environmental Engineering	Geotechnic and Offshore Wind
				 <div style="position: absolute; top: 10px; right: 10px; border: 2px solid white; padding: 5px; transform: rotate(-15deg); font-weight: bold; color: white;">Focus</div>
<ul style="list-style-type: none"> • Hydrogeology • Water resource Management • Water abstraction and treatment • Pumping stations • Distribution networks • Rural and Urban Sanitation • Sewage and sludge treatment plants • Wastewater reclamation • SCADA systems 	<ul style="list-style-type: none"> • Hydrology / Hydraulics • River engineering • Flood defense / Coastal protection • Restoration / development of aquatic systems • Waterway engineering including locks • Hydropower plants and storage dams • Harbor construction 	<ul style="list-style-type: none"> • Traffic planning • Public Transport Concepts • Transportation development concepts • Transportation infrastructure (roads, railroads) • Noise control • Integrated infrastructure concepts • Sustainable urban development • Road maintenance 	<ul style="list-style-type: none"> • Solid waste management / Sanitary landfill planning • Rehabilitation of contaminated sites / Area recycling • Groundwater protection • Environmental impact assessments Green space planning • Immission control (noise, air pollutants) • GIS (geo data, environmental monitoring) 	<ul style="list-style-type: none"> • Geotechnical Engineering • Soil investigations • Foundations • Design review • Certification • Pile Driving • UXO • Scour protection • Laboratory testing <p>In corporation with FICHTNER Group:</p> <ul style="list-style-type: none"> • Energy Yield • WTG technology • Electrical engineering • Due Dilligence

Agenda

Grundlagen und Annahmen

Kostenbestandteile + Energieertrag

Stromgestehungskosten

Vergleich + Interpretation

Agenda

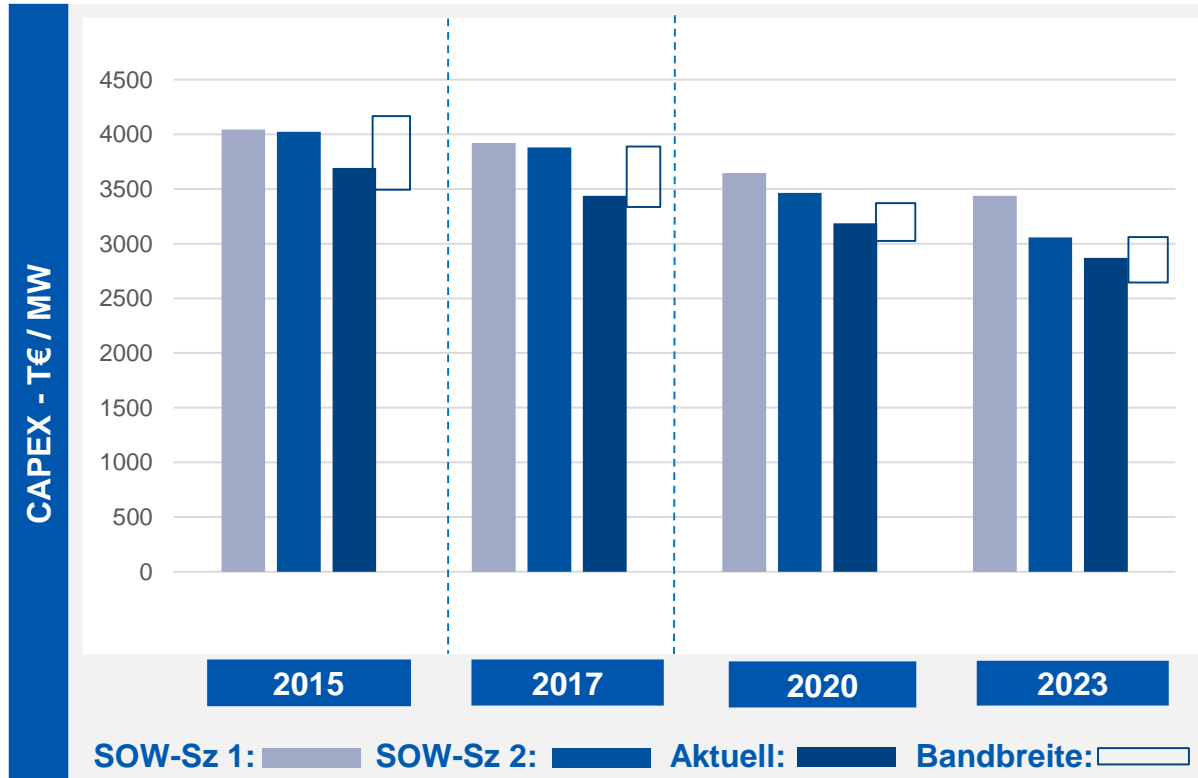
Grundlagen und Annahmen

Kostenbestandteile + Energieertrag

Stromgestehungskosten

Vergleich + Interpretation

Kostenbestandteile: CAPEX



Beschreibung

Projektentwicklung / - Management

- Lernkurve / Vereinheitlichung

Versicherung

- Abdeckung der Risiken

Turbine

- Leistung + Rotordurchmesser

Gründungsstruktur

- XXL MP + Optimierte Jackets
- Serienfertigung

Installation

- Großgeräte + Optimierungen

OSS

- Standardisierung + Optimierungen

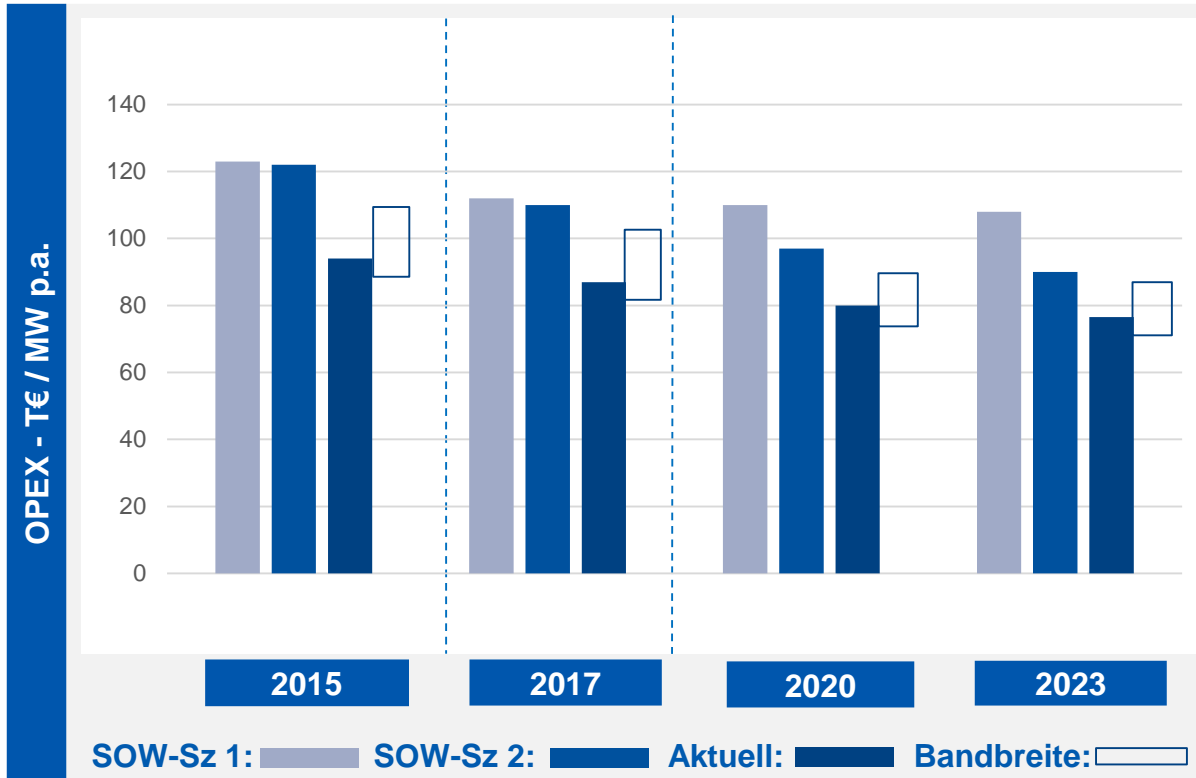
Reserve

- Lernkurve + Robustheit

Zentrale Punkte

- Zentraler Treiber ist die Entwicklung der Turbinen: Steigerung der Leistungsklasse und Rotordurchmesser
- Risikoreserve spielt eine wichtige Rolle
- Lernkurven in allen Bereichen der Projektentwicklung – und Projektausführung

Kostenbestandteile: OPEX



Beschreibung

Wartungsintervalle

- Optimierung
- Verbesserte Zugänglichkeit / Erreichbarkeit
- Verbesserte Infrastruktur

Versicherungen

- Anpassungen

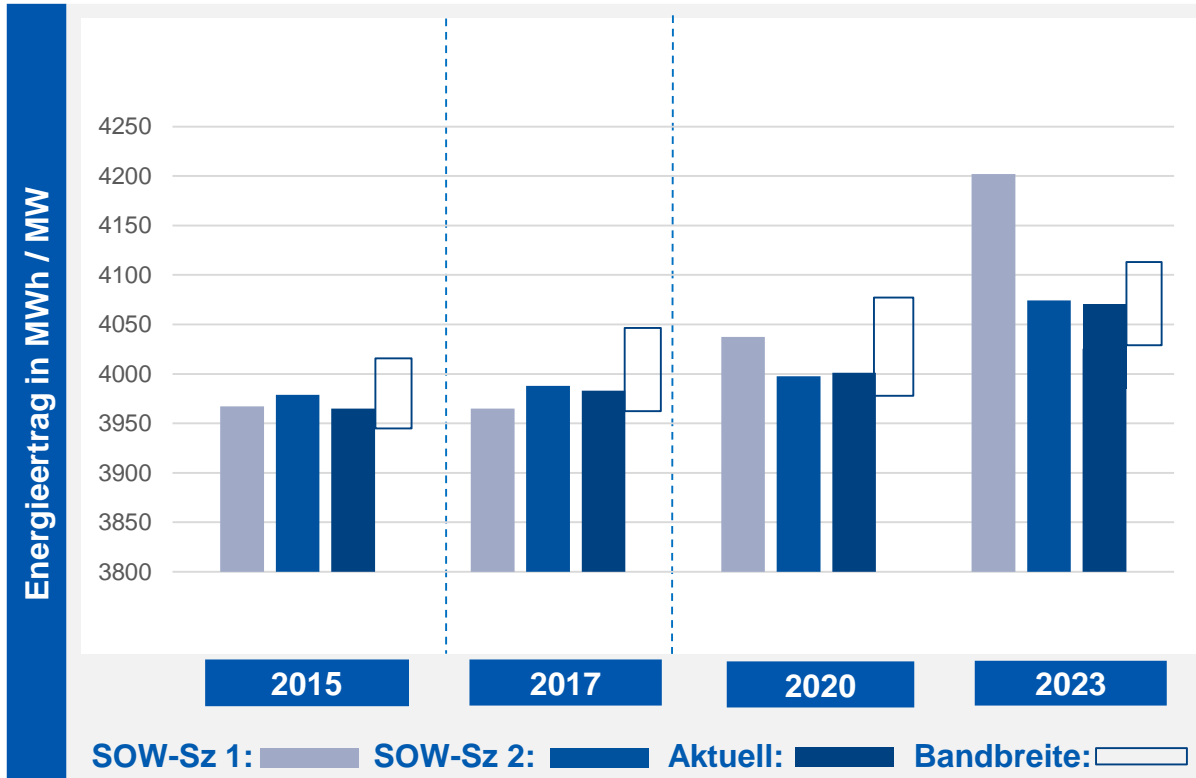
Konzepte

- Wartungplattform vs. Crew Vessel

Zentrale Punkte

- Gemeinsame Wartungskonzepte für mehrere Parks
- Optimierung der Wartungsintervalle
- Verbesserung der Erreichbarkeit (Zugangssysteme, Schiffe, Helikopter etc.)
- Zustandsüberwachung per Ferndiagnose

Energieertrag



Beschreibung

Bruttoenergieertrag

- Leistungssteigerung vs. Etablierte Technologie

Abschattungsverluste

- Extern + Intern

Weitere Verluste

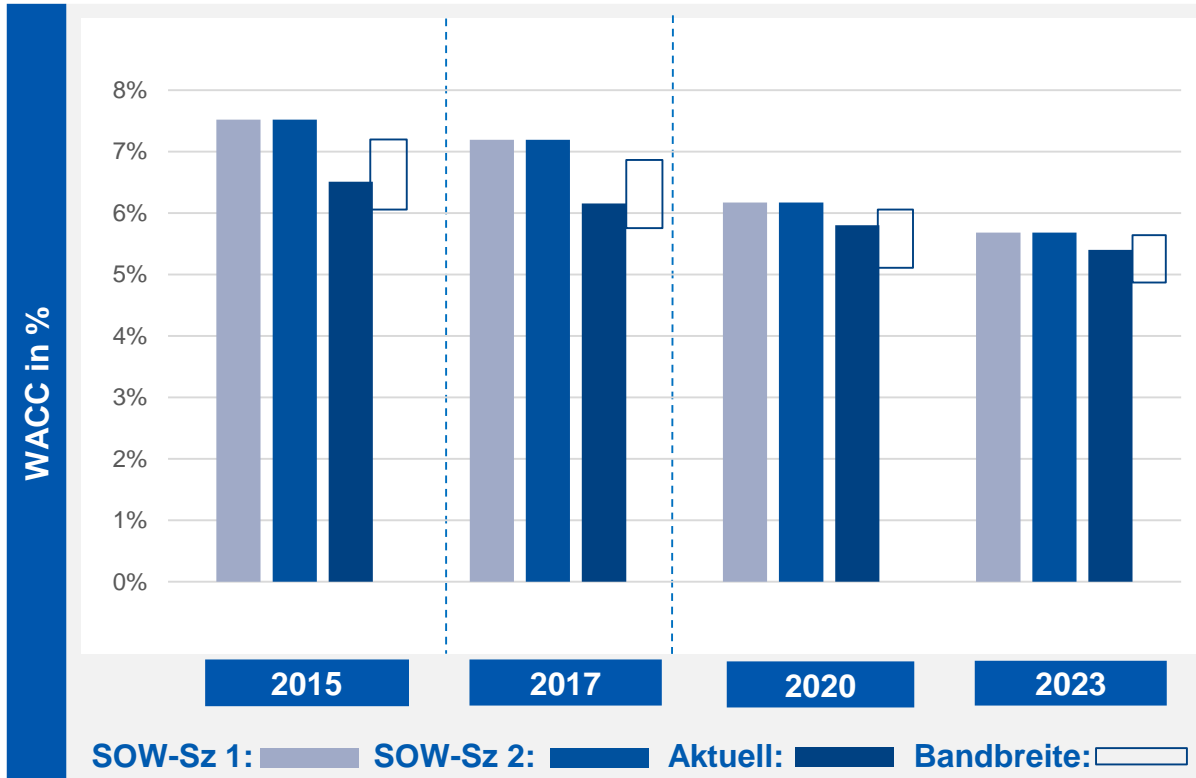
- Verfügbarkeit
- Elektrische Verluste
- Sonstige Verluste

Kapazitätsfaktor

Zentrale Punkte

- Turbinenentwicklungen bestimmen den weiteren Verlauf
- Entwicklung von Externen Abschattungsverluste ist ein zentraler Hebel
- Exkurs: Kapazitätsfaktor

Kapitalkosten - WACC



Beschreibung

Finanzierungsanteil

- EK vs. FK

Fremdkapital

- Darstellung der FK-Renditen

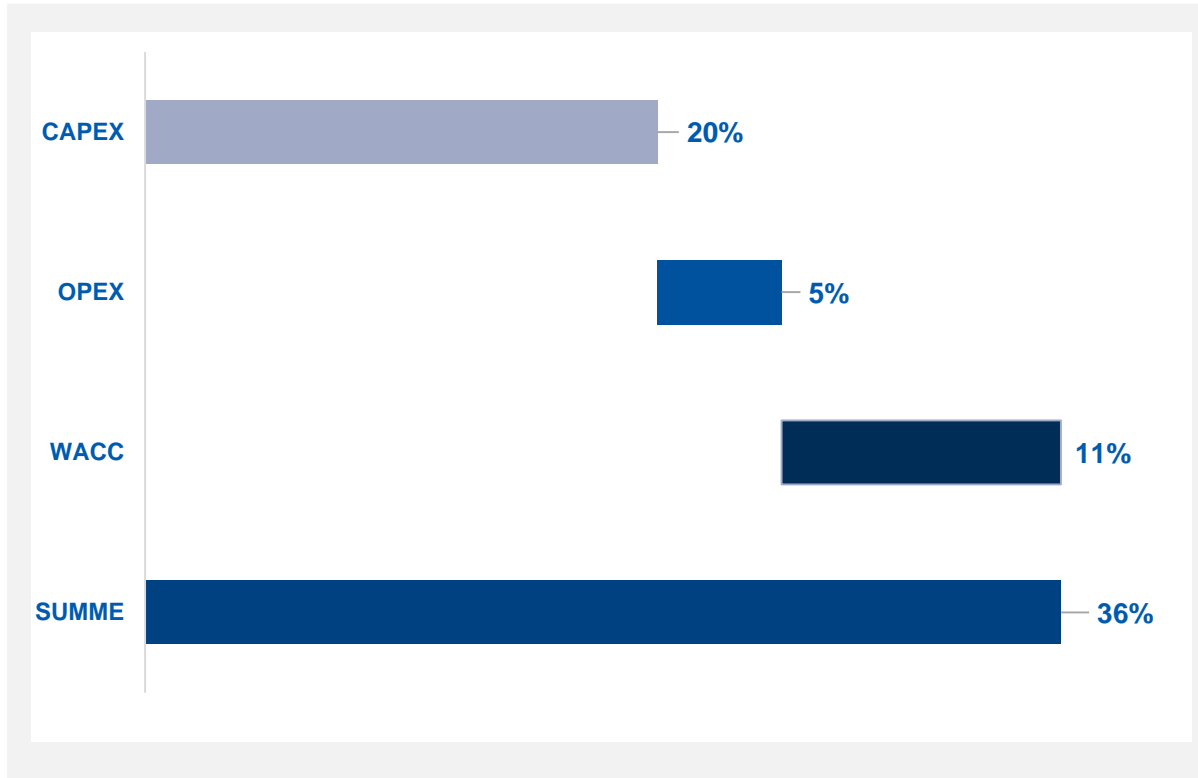
Risikoaufschlag

- Spiegelt Reifegrad der Industrie wieder

Zentrale Punkte

- Reifungsgrad der Industrie / Projekte bestimmt den Risikoaufschlag in der Finanzierung
- Niedrige FK – Finanzierungskosten
- Senkung der EK-Anforderungen

Kostensenkungspotentiale



Beschreibung

WACC

- Steigerung WACC: 1% führt zu einer Steigerung der LCOE: 6%

Zentrale Punkte

- Ca. 2/3 der Kostensenkungspotentiale entfallen auf die Verbesserung der Technik
- Ca. 1/3 der Kostensenkungspotentiale wird durch Kapitalkosten erschlossen

Agenda

Grundlagen und Annahmen

Kostenbestandteile + Energieertrag

Stromgestehungskosten

Vergleich + Interpretation

Stromgestehungskosten: Tendenzen



Beschreibung

Basis

- Unter Annahme der Entwicklung von CAPEX, OPEX, Energieertrag, WACC und Rückbaukosten

Agenda

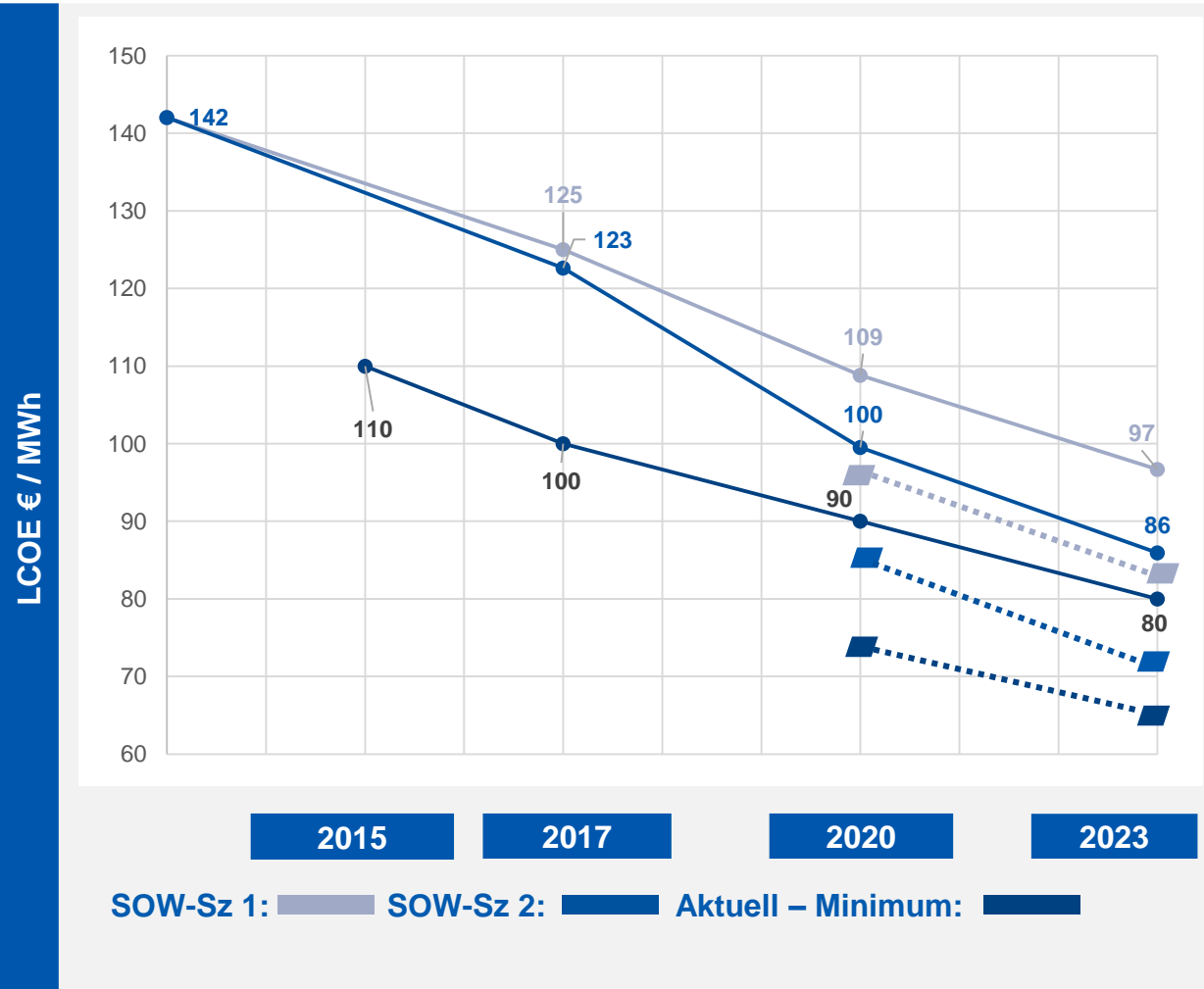
Grundlagen und Annahmen

Kostenbestandteile + Energieertrag

Stromgestehungskosten

Vergleich + Interpretation

Stromgestehungskosten: EU-Vergleich

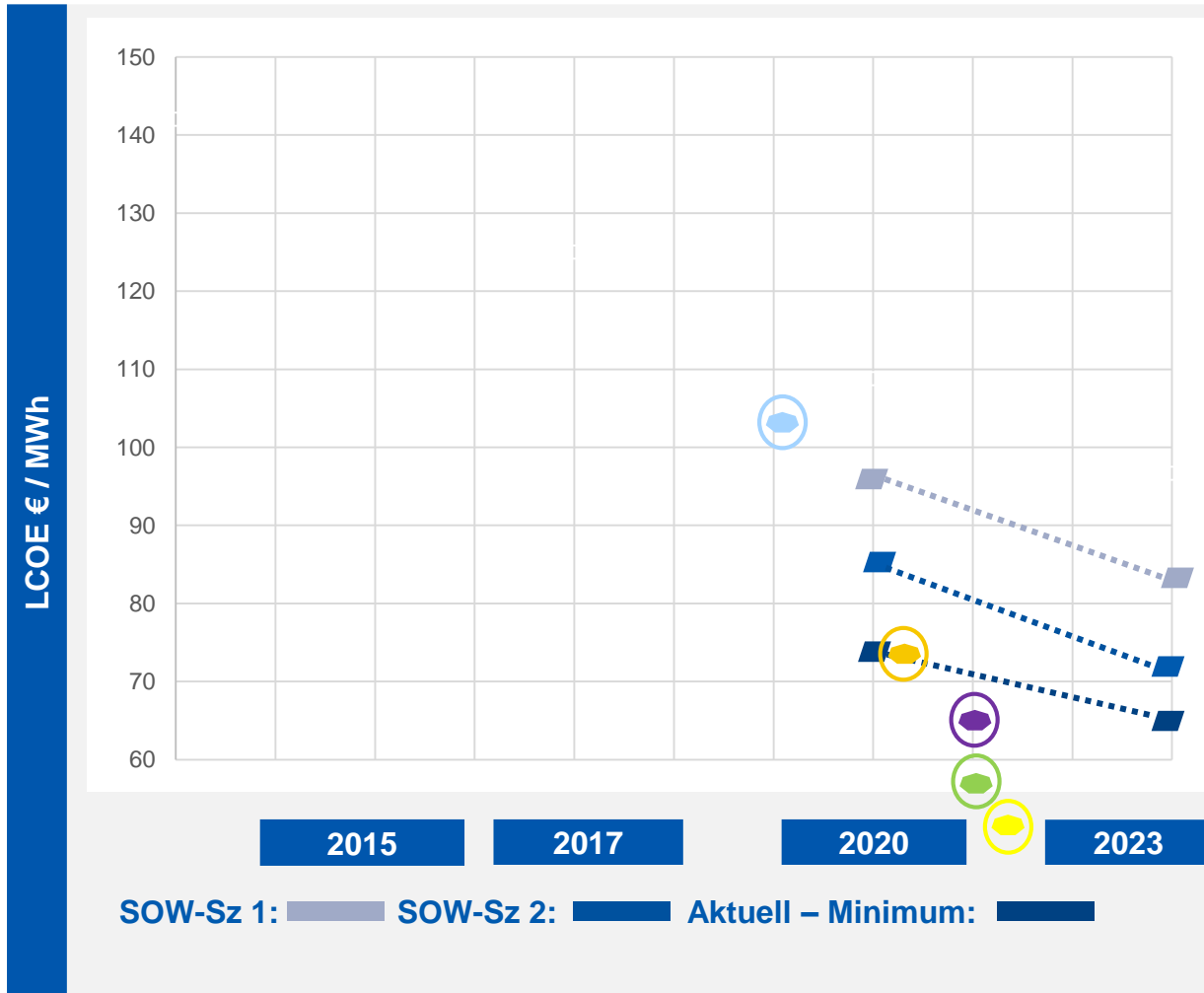


Beschreibung

Anpassungen – LCOE Deutschland

- Exklusive OSS = ca. 14€ / MWh
- Anpassungen der Entwicklungskosten

Stromgestehungskosten: Modellierung + EU - Vergleich



Beschreibung

Anpassungen – LCOE Deutschland

- Exklusive OSS = ca. 14€ / MWh
- Anpassungen der Entwicklungskosten

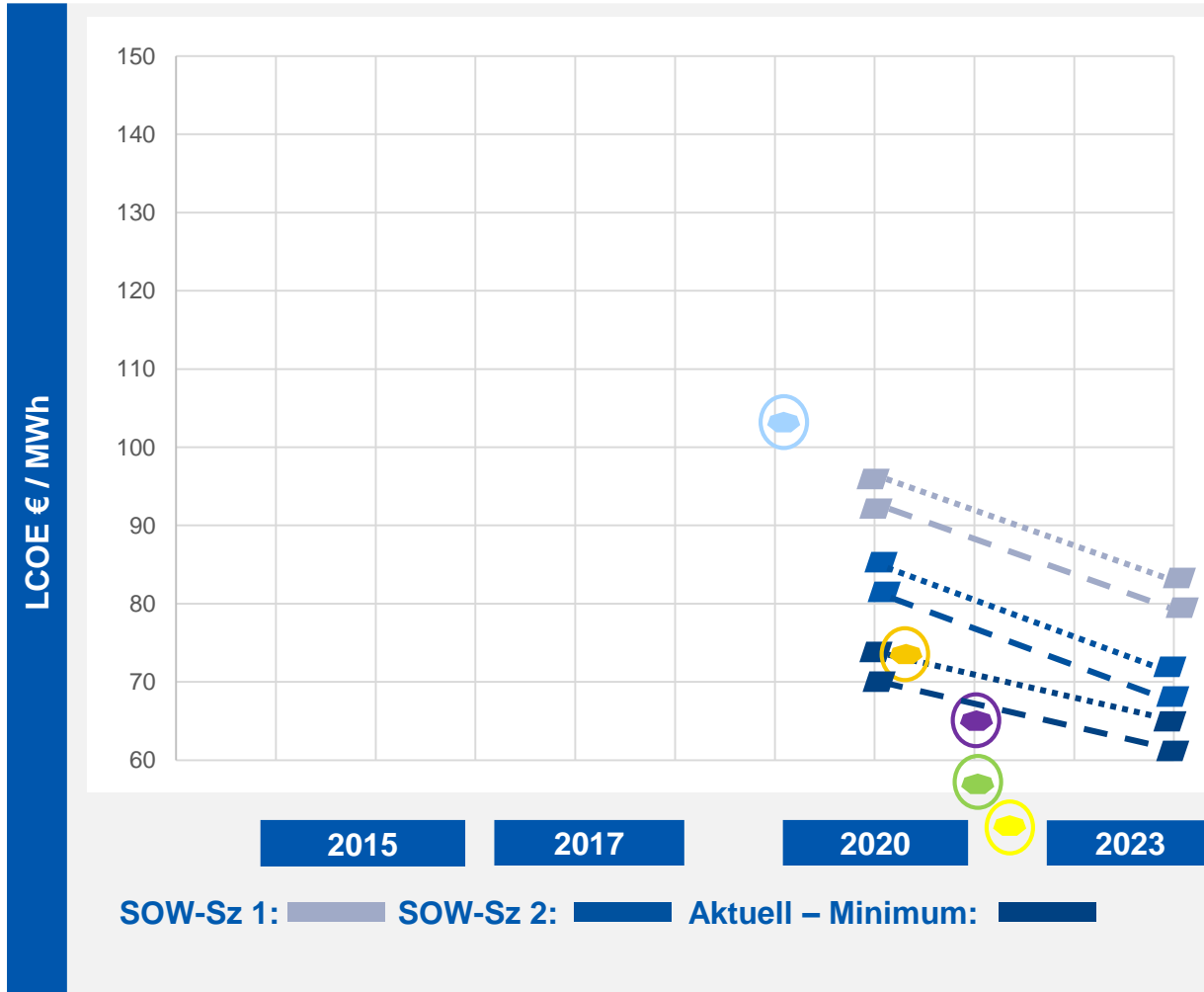
Ausschreibungsergebnisse

- Horns Rev III (DÄN) = 103,1 €/MWh ○
- Borselle I+II (NLD) = 72,7 €/MWh ○
- Vesterhav (DÄN) = 63,8 €/MWh ○
- Borselle III + IV (NLD) = 54,4 €/MWh ○
- Kriegers Flak (DÄN) = 49,9 €/MWh ○

Hinweis

- Keine Anpassung nach [Wassertiefe](#) und [Küstenentfernung](#)

Stromgestehungskosten: Modellierung + EU - Vergleich



Beschreibung

Anpassungen – LCOE Deutschland

- Exklusive OSS = ca. 14€ / MWh
- Anpassungen der Entwicklungskosten
- Modellierung 25 Jahre Betriebsphase ≡ ≡

Ausschreibungsergebnisse

- Horns Rev III (DÄN) = 103,1 €/MWh ○
- Borselle I+II (NLD) = 72,7 €/MWh ○
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Hinweis

- Keine Anpassung nach **Wassertiefe** und **Küstenentfernung**

Kontaktpersonen – Offshore Wind

FICHTNER Water and Transportation GmbH - Hamburg

Hammerbrookstr. 47b
20097 Hamburg



Geschäftsführer

Dr. Hartmut Tworuschka

Telefon +49 (0)40 300673-100

Telefax +49 (0)40 300673-110

Mobil +49 (0)49 151 4020 2266

E-Mail hartmut.tworuschka@fwf.fichtner.de

www.fwt.fichtner.de

www.fichtner.de



Leiter Offshore Wind - Hamburg

Maik Richter

Telefon +49 (0)40 300673-406

Telefax +49 (0)40 300673-110

Mobil +49 (0)157 73736 332

E-Mail maik.richter@fwf.fichtner.de

www.fwt.fichtner.de

www.fichtner.de

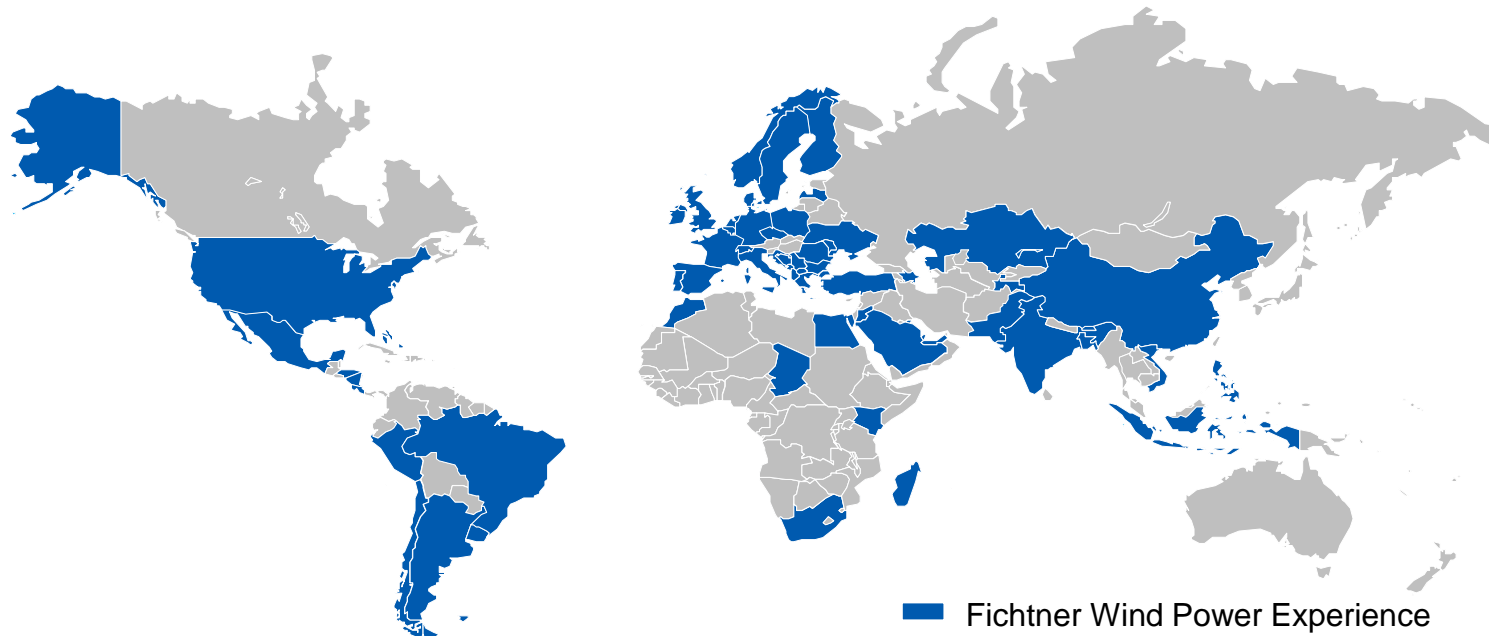
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Group Wind power experience - overview

Competence Centers in Germany (Stuttgart, **Hamburg**), Italy, UK and Turkey
Fichtner realized more than 350 projects with a capacity of **28 GW**, among others:

- **Involved at approximately 25 offshore projects**
- 150 lenders engineering projects
- 40 owners engineering projects and 40 studies in connection with wind power



Corporate information: FICHTNER

FICHTNER is an international, independent provider of engineering and consultancy services

FICHTNER worldwide

FICHTNER

GROUP

Founded in: 1922

29 subsidiaries and affiliated companies in over 50 countries

1500 employees of whom almost 800 are based in Germany

285 m€ turnover



FICHTNER

WATER & TRANSPORTATION

Founded in: 2003

Offices in Stuttgart, Essen, Freiburg, Hamburg and Leipzig

217 employees

27.2 m€ turnover

Kunden / Partner



Offshore Wind Referenzen – Overview (1/4)

Project	Client	Scope of Services	Date
Global Tech I	Global Tech I	Pile Driving Analysis	2017
North Sea	Confidential	Mandate as a technical advisor and full Technical Due Diligence for an OFTO during bid stage	2017
Confidential	Vattenfall	Pile Driving Analysis	2017
North Sea	Confidential	Due Diligence Evaluation of technical concept and scheduling / permitting risks	2016 - 2017
North Sea	Confidential	Factual axial pile capacity derived from analysis of driving data	2016
North Sea	Confidential	Check of required monopile penetration to comply with design criteria	2016
Renewable Energy Act Study	BMW i	Regulative effects from German Renewable Energy Act on costs and development of Offshore Wind Power in Germany	2016 - ongoing
North Sea	Confidential	Check of lateral monopile resistance during installation, incl. determination of allowable pile inclination and hydrodynamic loading	2016
North Sea - UK	Confidential	Technical Due Diligence – 570 MW	2016
North Sea - UK	Confidential	Technical Due Diligence – 250 MW	2016
Race Bank	Bilfinger Mars Offshore	Project Management – Fabrication of 91 Transition Pieces	2015 - 2017
Baltic II	nkt Cables	As-build documentation for ACDC-grid connection	2015 - 2016
German North Sea	ThyssenKrupp	Vibratory driving predictions	2015
Sandbank	Vattenfall	Pile driving simulations, back analysis and predictions	2015

Offshore Wind References – Overview (2/4)

Project	Client	Scope of Services	Date
Borkum 2	Trianel	Geotechnical expert (development and construction phase), BSH support	2015 - ongoing
North Sea UK	Confidential investor	Mandate as a technical advisor and full Technical Due Diligence for an OFTO during bid stage	2015 - 2016
Various	Bilfinger Mars Offshore	Tender management for an foundation supplier of Transitions Pieces and Jackets	2014 - 2016
Bard I	OceanBreeze	Check of grid connection and stability in BARD Offshore 1 wind farm	2014 - 2015
Nordergründe	Bilfinger	Pile driving predictions	2015
North Sea UK	Confidential investor	Mandate as a technical advisor and full Technical Due Diligence for an OFTO during bid stage	2014 - 2015
Wikinger	Bilfinger	Field test concept for test piles (static and dynamic load tests), contractors representative, PDA, DLT, SLT, PDP	2014 - 2015
North Sea UK	Confidential investor	Technical advisor for an Offshore windfarm transmission asset (OFTO)	2014 - 2015
Baltic 1	EnBW	Consultancy on grout monitoring concept	2014 - 2015
Hohe See	Confidential	Design management and tender management for foundations, scour analysis and report	2014 - 2015
Scottish North Sea	Confidential investor	Due diligence for pension fund investment in a Scottish offshore wind farm with focus on Installation, foundation design, geotechnics and metocean, Port selection and grid connection study	2014
MEG 1	Hochtief	Design of scour protection	2014

Offshore Wind References – Overview (3/4)

Project	Client	Scope of Services	Date
Baltic 2	Hochtief, Deme	Pile driving simulations, fatigue calculations for jacket piles and Monopiles, demobilization support for the test piles	2014
Nordsee One	RWE Innogy	Fatigue calculations of piles and flange connections at VIBRO test field	2014
MEG I	Hochtief	Engineering Services for the offshore substation of the wind farm MEG1	2013
Cost Reduction Study	Stiftung Offshore	Cost Reduction Potentials of Offshore Wind Power in Germany	2013
Cost Reduction Study	Stiftung Offshore	Cost Reduction Potentials of Offshore Wind Power in Germany	2013
Westermost Rough	DONG Energy	Due diligence support with focus on the electrical package, including onshore and offshore substation, grid connection, offshore export and array cabling and SCADA/comms systems	2013
UK North Sea	OFGEM	Technical investigation of an Offshore Wind Farm Transmission Asset (OFTO). analysis and assess costs of the development and construction of wind farm transmission asset transfer to the Offshore Transmission Owner (OFTO).	2013
German North Sea	Confidential Investor	Technical due diligence for four converter platforms in the German North Sea	2013
Arkona Becken Süd Ost	E.ON Climate & Renewables	Scour Estimation	2012 - 2014
MEG1	UBS, EIG	Technical due diligence and Investor support within EPC negotiations	2012
Baltic I	EnBW	Assessment & Validation of the Grout Monitoring Concept	2012
NordseeOst	RWE Innogy	Scour Estimation & Protection Concept, installation procedures, material specifications	2012
Gode Wind I & II	Hochtief	Drivability analysis for tender	2012

Offshore Wind References – Overview (4/4)

Project	Client	Scope of Services	Date
GlobalTech1	Global Tech I Offshore Wind GmbH	Drivability Analysis, Geotechnical Consultancy, UXO, BSH support, Design Support Foundations, Scour Protection OSS, Jacking consultancy Wilhelmshaven	2011 - 2015
German North Sea	TenneT TSO GmbH	HVDC grid connection for offshore wind farms in the North Sea. Fichtner provide project steering and technical consultancy.	2011 - 2015
Nordergründe	Energiekontor, wpd	Consulting Services on Morphodynamics, structural design	2011 - 2013
Riffgat	JV GeoSea, Nordsee	Detailed Design of scour protection system, Model Testing	2011 - 2012
Butendiek	wpd	Review of EPCI tender returns for four main components – turbine, foundations, transformer substation platform and wind farm cabling.	2011
C-Power	Marguerite	Due diligence for an offshore wind farm in Belgium including review of documentation, project programme and wind yield.	2011
DanTysk	Vattenfall	Scour Protection: Tender and Preliminary Design	2011
Butendiek	wpd	Consulting Services on installation of scour protection system	2011
Gode Wind I & II	Hochtief	Drivability analysis for tender	2012
Meerwind Ost and Sued	WindMW GmbH	Design and monitoring of Scour Protection, Jacking consultancy Esbjerg	2010 - 2014
Baltic II	Hochtief, Geosea, Nassbagger	Independent Design Check, Drivability Studies, Certification BSH Support	2010 - 2012
Baltic II	Hochtief	Scour protection: Investigation of scour behaviour	2009 - 2012
Wetfeet	Windreich	Review of contracts, project & risk management, permit application management & technical advisory for O&M concept, marine logistics, turbine erection, electrical and I&C systems.	2009 - 2010