

OFFSHORE WIND

A MANIFESTO FOR COST REDUCTION

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FOREWORD

We are living in a time of transition.

It is a time of opportunities and rewards but also a time of risks and difficult decisions for the energy industry.

Geopolitical instability, serious concerns around nuclear power and, of course, the overhanging threat of climate change are all driving change. After decades of stable and relatively predictable conditions our energy world is now shaking at the core; the utility giants' business models are crumbling. Few doubt that we are facing an energy revolution - but it is virtually impossible to foresee the path it will take.

Harvesting the abundant wind energy resources of the seas provides an opportunity to generate huge volumes of affordable, clean and reliable power. However, as with any new undertaking, the offshore wind energy industry is still learning the lessons that allow costs to fall in line with other electricity generation technologies. As we show in this document, cost reduction will be won through small changes to practice as often as through headline-grabbing leaps in technology.

This year, we in DNV GL celebrate our 150th anniversary and also the formation of our new organisation. Offshore wind is the point where all the core businesses of DNV GL meet. Our strong legacy in maritime, offshore engineering, renewable energy, power transmission and marine operations mean that we have the ability to understand the whole value chain, scan the cost reduction landscape, take the broader view and chart a course. We are fully committed to making this industry cost competitive as soon as possible. Needless to say, it is a remarkable challenge to bring down the cost of offshore wind by 40% or even 50%, but the document you hold in your hand is an important stage in the mission to get there.

This manifesto for cost reduction does not only present the state of offshore wind cost reduction as we see it, based on our own hands-on experience and advanced modelling capability. It is also a statement of our commitment, a declaration of our intention and a programme for action. Perhaps most importantly, it is an invitation to join with us to make sure that offshore wind lives up to its potential.



Johan Sandberg
Service Line Leader, Offshore Renewables
DNV GL – Energy

Wir haben in Deutschland bereits viel erreicht, um Offshore-Windenergie im Energiemix fest zu etablieren. Die installierte Leistung der Offshore-Windenergie wird in Deutschland bis zum Jahr 2020 auf mehr als 6.000 MW geschätzt. Bis Ende 2015 soll Deutschland voraussichtlich über eine Offshore-Windkapazität von 3.300 MW verfügen. Doch mit der steigenden Leistung muss die Offshore-Windenergie auch billiger und damit wettbewerbsfähig werden, darüber sind sich Industrie und Politik einig. Bis 2020 sollen die Kosten – so die Herausforderung für die gesamte Branche – um 40 Prozent sinken. Die klar definierten Ziele für Stromgestehungskosten verlangen nach Initiativen, welche die Kostenreduzierungen in nachhaltiger Weise realisieren, und das innerhalb der nächsten 3-5 Jahre.

Wir bei DNV GL wissen, dass vieles schon heute möglich ist und der Bericht, den Sie in den Händen halten, ist ein wichtiger Baustein, um Kostenreduzierungspotentiale jetzt freizusetzen. Unser "Offshore Wind Cost Reduction Manifesto" zeigt, wie wir bei DNV GL das Potential zur Kostenreduzierung sehen und erläutert Handlungsempfehlungen für alle Marktteilnehmer auf dem Weg hin zu einer erfolgreichen und wettbewerbsfähigen Offshore-Windindustrie.

Insbesondere freue ich mich, dass wir den Bericht erstmals in Hamburg der gesamten Branche vorstellen können: Hamburg hat sich mittlerweile eindeutig als Dreh- und Angelpunkt der deutschen Offshore-Windenergie-Aktivitäten etabliert, und wir wollen, dass das auch in Zukunft so bleibt.

Ich wünsche Ihnen viel Spaß mit dieser Lektüre.



Andreas Schroeter
Executive Vice President
DNV GL – Energy

INTRODUCTION

Cost reduction has been the watchword of the offshore wind industry for the last five years; and rightly so. Reducing the cost of energy is our side of a grand bargain with governments around the world, whose support is still vital for our industry's transition from a rookie with big ambitions to a mature energy source.

So a war on cost has been declared and numerous reports drafted, meetings convened, conferences attended, cost reduction opportunities listed. There have certainly been a lot of words dedicated to waging the war and one could be mistaken for thinking that talking about cost reduction had become an industry unto itself. But what about in the real world: has there been any tangible progress? Are offshore wind costs falling?

In the main markets for offshore wind the short answer to these questions is an encouraging if qualified, 'yes'.

Bigger, more reliable turbines are becoming available far faster than predicted while the offshore wind supply chain in general is a more competitive place that it ever has been. Standardisation of important wind farm elements is starting to emerge and companies are starting to share performance data. Turbine performance, as measured by load factors, is up and offshore wind is going global with a strong pipeline of projects in U.S. and China. In Europe, the table on the right shows the range of cost reduction initiatives which are ongoing across the lifecycle - many of which are starting to bear fruit.

Importantly, offshore wind is winning the PR battle; for example, 77% of the British public approve of the technology compared to 47% for

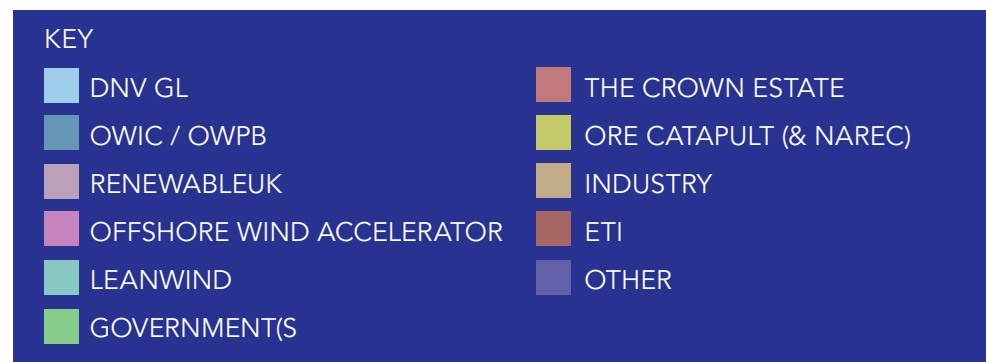
nuclear power or just 29% for shale gas produced by hydraulic fracturing¹. The fact that costs are falling is underscored by the continuation of projects in countries where the level of support for offshore wind has been cut. Perhaps the most important indicator is how offshore wind is viewed by financial markets and, after a long wait, debt finance is finally starting to make a meaningful appearance.

However, these signs that we are heading in the right direction are no reason to relax our efforts; there is a long way to go until offshore wind can hold its own against conventional generation technologies.

BROADER VIEW

OFFSHORE WIND COST REDUCTION INITIATIVES

The chart on the right seeks to capture major ongoing cost reduction initiatives within the offshore wind sector (excluding floating wind). It is split by lifecycle element and broad categories of the type of initiative. The colour of the box represents the party who is leading the initiative, hatching represents DNV GL involvement.



1. Department of Energy and Climate Change (2014) Public attitudes tracking survey (wave 9). <https://www.gov.uk/government/publications/public-attitudes-tracking-survey-wave-9>

DEVELOPMENT		TURBINES		FOUNDATION		ELECTRICAL		CONSTRUCTION		OPERATIONS			
Cost Reduction Monitoring Framework													
Project Director Community of Practice													
WP5													
ORJIP					Transmission knowledge hub						SPARTA		
Offshore UNITED													
SUT Geotech / geophys guideline						Insurers Code of Practice				ISO55001 Asset Management			
						CableRisk Recommended Practice		Marine Operations JIP					
OWA FLIDAR		Use the FORCE				Reference design for substations		New vessels		Next gen CTV			
OWA Turbulence layout optimisation		Bigger Turbines		Advanced Welding Techniques		66kv		Guiding & handling systems		Condition monitoring			
Wake measurement		Drive train improvements		XL Monopiles		AC optimisation		Vessel safety guidance		Modular/ self lifting cranes			
Site design optimisation for minimal LCoE		Blade design		SLIC		DC optimisation		Leanwind WP2		Leanwind WP4			
Leanwind WP1		Very long blades		Revised monopile design standard		Cable Installation JIP		Leanwind WP3					
Leanwind WP6						LFAC JIP		Fast feeder vessels		OWA Access			
Leanwind WP7						OWA foundations		Cable burial and risk mitigation				Jack-up vessel O&M study	
FINO 1						PISA		Tech qual. for HVDC JIP					
FINO 2						RAVE (Research at Alpha Ventus)		Overplanting					
FINO 3													
FINO Wind (DWD)													
G9													
RISE													
Leanwind WP8													

OUR MANIFESTO

NOT ANOTHER COST REDUCTION REPORT!

The offshore wind industry knows what needs to be done to reduce costs and progress is being made. We are heading in the right direction so it could well be argued that another report on cost reduction is simply going over old ground.

But this Manifesto for Cost Reduction does more than identify and quantify cost reduction opportunities. It sets out the challenge as we in DNV GL see it and commits us to action on what we believe are some of the most important issues.

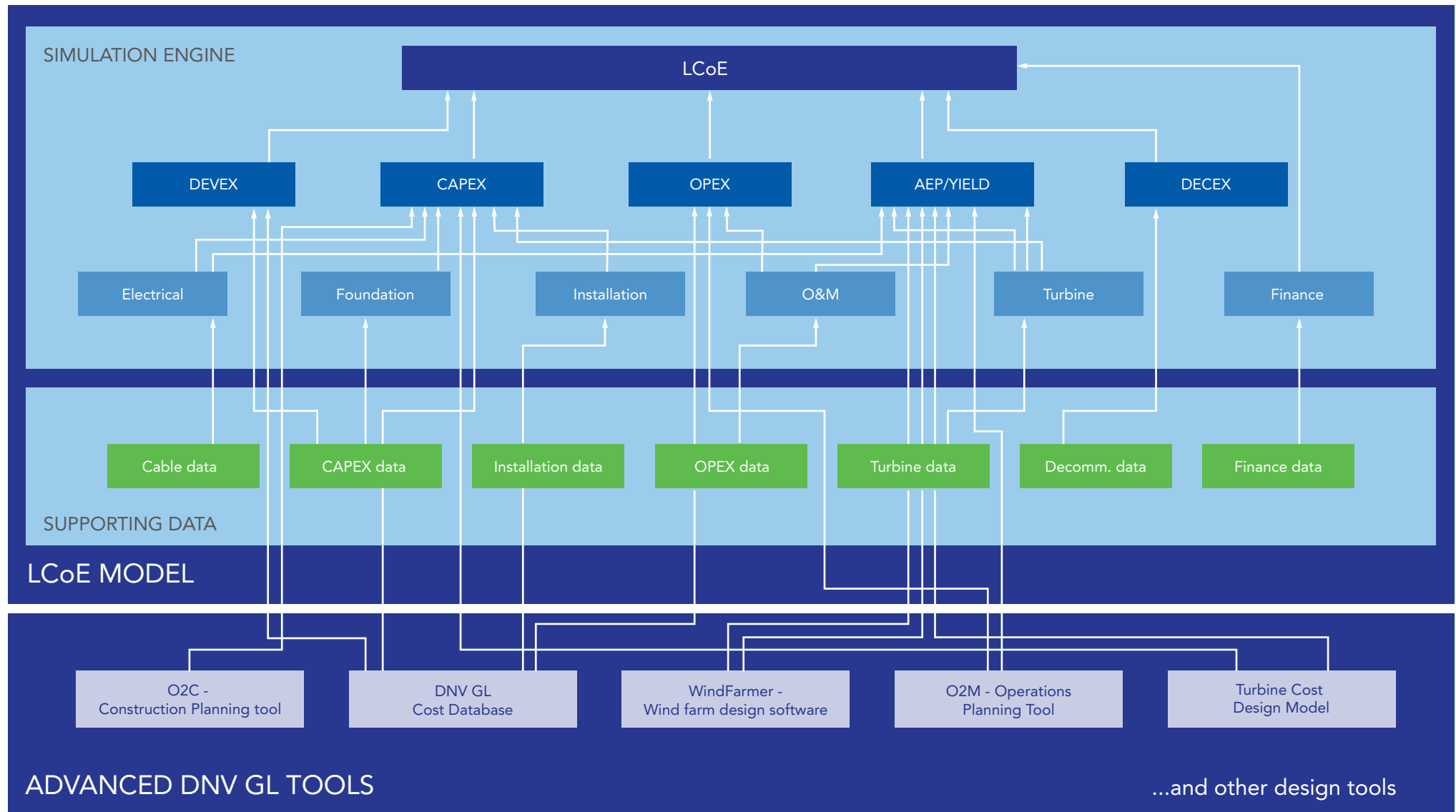
How do we know what will work? - Modelling the cost of energy

Understanding the factors that influence the cost of energy, their relative importance and how they interact is central to DNV GL's approach to the search for offshore wind cost reduction.

How it works

The DNV GL levelised cost of energy (LCoE) model is a tool to quickly calculate the cost of energy from a defined offshore wind project. Based on a powerful simulation engine, the LCoE model allows DNV GL engineers to tweak designs and explore the cost impact of potential cost reduction strategies.







THREE STRATEGIES

The cost reduction strategies we focus on in this report can be categorised into three basic types; doing it right, doing it better and doing it differently.

Do it right

Actions that focus on reducing risk and preventing mistakes, representing the potential to cut cost by around 7%

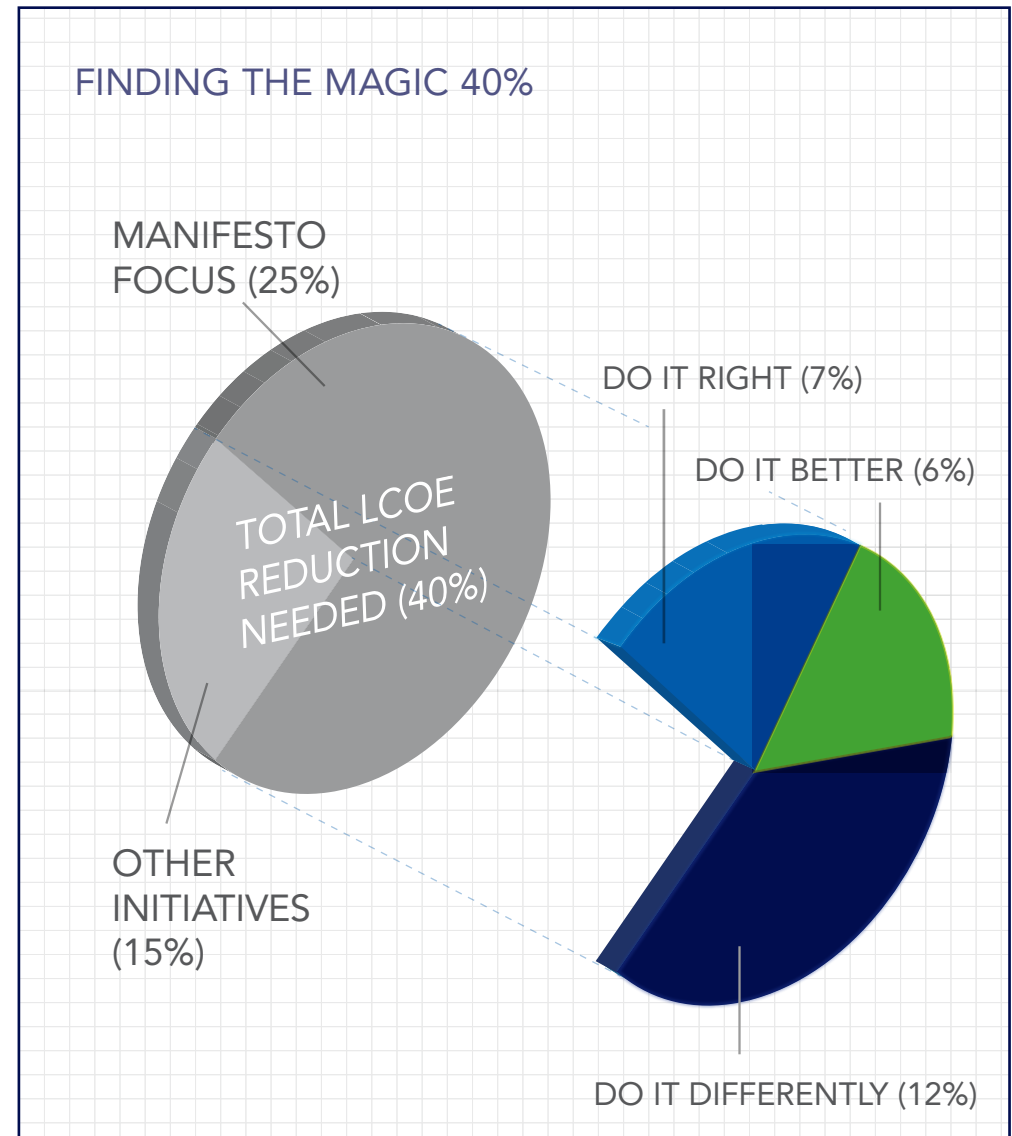
Do it better

Actions that focus on improving the efficiency of existing processes, representing a cost reduction potential of 6%

Do it differently

Actions which involve implementing alternative, innovative ways of doing things, representing around 12% cost reduction potential

There is broad consensus that a 40% reduction in cost is required by 2020 and, although challenging, it is achievable. The actions DNV GL commits to in this manifesto have the potential to collectively achieve reductions in the cost of energy of up to 25% with action in other important areas such as supply chain competition, standardisation and design life extension making up the remainder.



DO IT RIGHT

MANAGING RISK AND PREVENTING MISTAKES FOR CHEAPER, SAFER OFFSHORE WIND

Very few offshore wind projects that have been completed so far have been delivered on-time and within budget. Indeed, many projects have both taken longer and cost more to construct than anticipated. The effect of these overruns on the cost of energy is obvious. Every Pound or Euro overspent needs to be earned back. Every month that a project is late is a month that the wind farm cannot earn the revenues needed to pay its way.

And mistakes made during construction often have repercussions that the project will never be able to shake off. Construction errors can persist into the productive life of the project making operations harder, reducing production and adding to the ongoing costs. Operational processes themselves often cost more than they need to. The sector is yet to make the shift from simply operating wind farms to effective asset management.

As well as adding to the construction and operational cost of wind farms, risks to the time-scales and costs of building these colossal projects is reflected in the returns demanded by finance providers. Improving the certainty that a project will hit its budget reduces the cost of capital², a major component of the cost of energy in its own right

There are good reasons why construction of an offshore wind farm is the formidable engineering challenge that it is, but that doesn't mean that the process cannot be tightly managed. By preventing errors and 'doing it right', offshore wind can be made safer, capital and operational costs can be reduced, investors can be given certainty and, ultimately, energy can be made cheaper.

The kinds of actions needed to make sure the offshore wind industry can move in the direction of 'doing it right' are often not glamorous and sometimes seen as dull. But, by making small changes, by concentrating on doing things as well

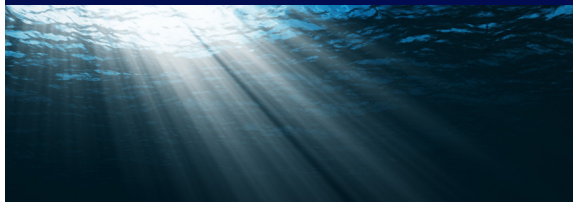
as they can be done, we believe cost savings of around 7% can be realised. Moreover, if we can't do it right, we are going to struggle to do it better. Doing it right is the key that unlocks other efficiencies and innovations, giving confidence to investors and governments.

2. Firstly by allowing current providers to lend more and / or at a lower rate. Then by making the sector available to cheaper, more risk averse capital.

DOING IT RIGHT - MITIGATING RISK AND INCREASING CERTAINTY

Poorly managed risks result in cost and time overruns. Mitigating risks is therefore key to doing it right. With over a decade of experience, the industry now has better cards to play to mitigate risk effectively.

Environmental



Risk

Wind, wave and tidal regime; ground conditions

Industry actions

Understand the site – collect sufficient wind, wave and tide data, SI following SUT & DNV GL guidance.

Use the right equipment - Charter appropriate vessels, tools and staff, understand real world working windows. Undertake sea trials of CTVs.

Plan appropriately - credible float, robust mitigations (incl. substitute vessels), contingency, insurance, effective construction and O&M modelling tools.

Management



Risk

Interface risk, supply delay and quality issues, grid connection, vessel availability

Industry actions

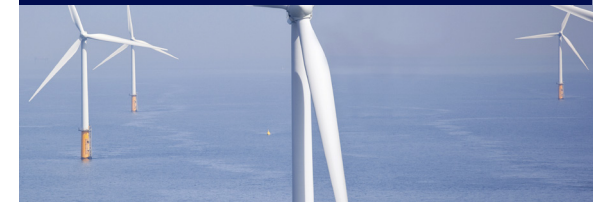
Plan appropriately – Repeat processes, use experienced contractors, bring supply chain into design, ensure credible float, robust mitigation plans, insurance and contingency.

Interfaces – minimise number of interfaces to a manageable level, use interface management specialists supported by advanced tools, clear and comprehensive contracts and common risk registers. Utilise interface workshops, use consistent language and share data.

Monitor and review – ensure robust QA and QC processes throughout the supply chain.

Grid – robust regulatory process, sufficient focus on onshore elements.

Technology



Risk

Design, new technology

Industry actions

Integrated project development – concept and pre-FEED studies to appropriate party with whole project and lifetime view, early engagement of supply chain in design, ensure contractual access to sub-suppliers with design responsibility, utilise layout optimising tools.

New technology - Appropriate testing and verification, demonstration sites, early engagement of financial community, DNV GL technology qualification approach.

DO IT BETTER

IMPROVING THE EFFICIENCY OF EXISTING PROCESSES

Even without costly mistakes there is room for improvement. The sector is still young and evolving the 'offshore wind' ways of working. There are opportunities to do it better, by identifying conservatism or inefficiencies. 'Doing it better' might be challenging design assumptions which were developed for a different sector, or perhaps moving away from the one-off type manufacturing processes suited for the oil and gas sector to more automated serial production optimised for offshore wind. Often these benefits only emerge across packages, with system thinking allowing greater optimisation.



DO IT DIFFERENTLY

INNOVATING FOR THE FUTURE

Finally, there are opportunities to save cost by abandoning old ways of doing things in favour of new, better ones. Sometimes, we just need to do things in a different way; innovating to discover new ways of solving problems is what created an offshore wind industry in the first place. This strategy involves more radical change, challenging traditions and pushing technical boundaries. In many ways this is the exciting face of innovation – big, radical – different. But at the same time it is challenging and risky.

There is a tension between 'doing it differently' and the other two strategies. Innovation can be risky. Unlike 'doing it right' which aims to mitigate risk or 'doing it better' which saves cost through efficiency, doing something entirely new brings with it new risks in the belief that they are justified by the benefit of reduced cost of energy.

The political environment in which we find ourselves is dictating the timetable for cost reduction. Failure to demonstrate cost reduction represents an existential threat to offshore wind. For this reason, DNV GL strongly supports focussing efforts where they will have the greatest, most certain impact on cost. 'Doing it right' and 'doing it better' together account for the majority of the opportunities for cost reduction, will improve the safety of those working in the sector AND represent the surest reduction in cost. It may not be glamorous, but only by diligently doing the difficult and dull can we fully realise offshore wind's potential.



OUR PLEDGES

COMMITTING TO ACTION

All those involved in offshore wind have a role to play in reducing cost. At DNV GL we pledge to take action to help our industry do it right, do it better and do it differently.

DO IT RIGHT

DNV GL shall...

- 🛩️ Launch a joint industry project (JIP) to improve Marine Operations in both the installation and operations phase
- 🛩️ Complete a cable installation JIP, which follows on from our recently published recommended practice guide to tackling subsea cable risks
- 🛩️ Help share operational data as a key technical advisor to SPARTA³ initiative
- 🛩️ Provide the industry with interface risk management
- 🛩️ Implement a methodology for assessing crew transfer technologies and techniques
- 🛩️ Help to ensure the safe and effective application of HVDC technology

DO IT BETTER

DNV GL shall...

- 🛩️ Launch "Offshore UNITED" - a JIP to drive collaborative and integrated approaches to project development, design and engineering
- 🛩️ Optimise monopile design standards
- 🛩️ Deliver better site design through an enhanced range of planning and optimisation tools
- 🛩️ Help the industry optimise the sizing of export electrical systems
- 🛩️ Help move jacket fabrication towards serial production methods

DO IT DIFFERENTLY

DNV GL shall...

- 🛩️ Use the FORCE – a collaborative R&D project to show how the cost reduction potential identified in project FORCE can be applied on a real world project.⁴
- 🛩️ Continue to push the technological limits of turbine design – especially with regard to larger turbines
- 🛩️ Continue to drive the commercialisation of floating wind

3. (System Performance, Availability and Reliability Trend Analysis)

4. Project FORCE was a DNV GL research and innovation project executed in 2013 and published in 2014. It examined the benefits of adopting an integrated approach to the design of wind turbines and their supporting structures. Find out more at dnvgl.com/renewables


CONCLUSION

It has been shown time and again that offshore wind can be a lot cheaper than it currently is – and there are now very positive signs that we are moving in the right direction.

As well as a commercial interest in the future of offshore wind, DNV GL has an obligation to ensure that every effort is made to open up this abundant energy source as widely as possible. Coming good on this obligation and the opportunity afforded by our involvement in all elements of the offshore wind value chain, we are able to make 14 commitments to act. Together, these may cut the cost of energy by up to 25%.

We do not propose that DNV GL can do any of these things alone. The pledges in this manifesto set out what we hope to achieve by working in close collaboration with the developers, OEMs, contractors, financiers, governments and regulators that work hard every day to make the offshore wind industry the success that it is. We offer our commitment, and seek yours, to work together for a cost competitive, global offshore wind industry.

There is much work to do. To achieve the deep cost reductions required to secure its future, the offshore wind industry will need three things: commitment, partnership and focus. This manifesto document lays out our commitment to reducing the cost of offshore wind energy alongside our industrial and governmental partners. And, in the limited time available, only by carefully focusing the industry's resources can we achieve our goals. There is no doubt that grand innovation is important for the future of offshore wind but, as our analysis shows, step-wise, unglamorous changes to practice –doing it right and doing it better– are just as important.



We offer our commitment, and seek yours, to work together for a cost competitive, global offshore wind industry.

DO IT RIGHT

MANAGING RISK AND PREVENTING MISTAKES FOR CHEAPER, SAFER OFFSHORE WIND

Marine Operations Joint Industry Project



Successful marine operations are key to delivering projects on time and on budget. During installation, marine operations are the major driver of cost and in the operations phase, marine logistics still account for around a third of OpEx. Currently, there is no offshore wind specific guidance to how to comply with standards and guidelines for marine operations, with the sector still borrowing from oil and gas.

DNV GL is launching a Joint Industry Project (JIP) to develop recommended practice guidelines for marine operations. This project will seek to develop guidance related to specific issues such as guiding & handling systems, dynamic lifts, jacking operations, sea transport and sea fastening, safe and optimal in-field logistics, installation and access vessel requirements (including functional requirements, constructability assessments and operational reviews) and logistic requirements for cable installation. It will help ensure safer, more effective marine operations.

Reducing Cable Installation Risk



80% of offshore wind insurance claims are due to cables and cabling issues continuing to challenge the industry. In response DNV GL recently completed a major JIP, publishing a recommended practice guide seeking to manage cabling risk across the whole lifecycle. It is being followed up with a €1 million JIP (with the oil and gas sector) to develop three guidelines which will provide guidance on analysis scope and methodology, as well as load effects, and acceptance criteria for installation of subsea power cables, flexible pipes, umbilicals and rigid pipelines.

The project included 20 partners including Statoil, NEXANS, ABB, VSMC, Technip, Tideway, KW/Petrofac, Heerema, EMAS and Subsea 7.

SPARTA - System Performance, Availability & Reliability Trend Analysis



Benchmarking and comparison against peers is an established part of mature power generation industries. The oil and gas industry has had a successful reliability data scheme called OREDA since 1981. Without a similar platform, offshore wind operators are unable to compare the performance of their assets against others.

DNV GL are involved in a pioneering collaborative cross-industry project to share anonymised offshore wind farm performance and maintenance data, providing owner/operators with robust and reliable benchmarking data.

DNV GL and The Crown Estate scoped out the design with Offshore Renewable Energy Catapult now leading the implementation. The project is currently in its pilot phase, with 9 developers submitting data. DNV GL sits on the steering group and is contracted as the technical advisor, auditing the processes and data and helping give confidence in the results to operators.

Managing Interface Risk



The offshore wind project lifecycle spans several years and involves a diverse and evolving cast of contracting entities. As a result, effectively monitoring and managing contract interfaces and the flow of project information is extremely challenging. Any confusion over contractual responsibility or dispute about variations from scope inevitably leads to cost overruns and delays.

DNV GL works to provide interface management support that draws on real world experience of managing the construction of offshore wind farms.

Sea Trials of Crew Transfer Vessels



Access - the ability to put engineers on turbines in all weather conditions - is a significant driver of turbine availability and therefore LCoE.

With a range of innovative solutions coming to market, DNV GL has been working with The Carbon Trust since 2012 to assess vessel performance in transit, transfer and turbine approach in different environmental conditions and evaluate transit times. DNV GL has developed sea trial procedures and a performance evaluation methodology for crew transfer.

The methodology allows reliable assessment of potential access techniques and vessels, providing operators with greater confidence and detail of the operational limits when transferring technicians to turbines

A better understanding of the real world capabilities of access systems helps improve safety of transfers, aids O&M planning and increase turbine availability.

Qualification Procedure for Offshore HVDC Technologies



Operational experience with offshore HVDC transmission technologies is very limited and there is a lack of relevant standards, guidelines and recommendations for stakeholders to rely on. The immature nature of the technology causes uncertainty and increased risk exposure and makes projects complicated and costly.

A DNV GL-led JIP to apply our tried-and-tested technology qualification criteria to HVDC transmission technologies has resulted in a new recommended practice document, launched in August 2014. This document helps manage technology risk and will help ensure that the new technology will function within the specified limits.

Partners in the project included ABB, Alstom Grid, DONG Energy, Elia, Europacable, Scottish Power, Statkraft, Statnet, Statoil, Svenska Kraftnat and Vattenfall.

DO IT BETTER

IMPROVING THE EFFICIENCY OF EXISTING PROCESSES

Offshore UNITED - UNderstanding Integrated Technology, Engineering and Project Development



The design phase of a project offers the greatest opportunity to influence outturn costs. And, although there has been much talk of integration in design and development, the industry is struggling to put it into practice. More work is needed to bring the supply chain into the design process and explore how an integrated approach to development would work.

DNV GL is planning to launch a Joint Industry Project in 2015 which promotes a collaborative and integrated approach for project development, engineering and procurement.

Optimise Monopile Design Standards



Reduced conservatism in monopile design can cut costs considerably.

Having reviewed design assumptions relating to the fatigue life of butt welds in monopiles, DNV GL has revised the DNV-RP-C203 and DNV-OS-J101 standards. The changes could result in a reduction in steel weight of 7-15% for thick monopiles (80-100mm), with a corresponding reduction in welding time. DNV GL is committed to improving and revising our design standards on a timely basis.

Deliver better site design



O2C
Optimisation of
offshore construction

Getting the design right up front is a means to delivering better projects. Through a well-managed front-end engineering and design (FEED) process supported by the appropriate analytical tools, cost can be reduced significantly.

DNV GL has a range of tools that can help developers optimise design for reduced LCoE. These include construction and operation simulation (O2C & O2M), wake modelling (WindFarmer), multi-variable layout optimisation (being developed for the Offshore Wind Accelerator) and a Monte-Carlo CapEx risk analyser. As the sector gains experience, DNV GL will continually develop these cutting edge tools to provide the best advice to our customers.

Optimising size of export electrical systems



Offshore transmission links to date have been sized conservatively, without due consideration of the actual generation profile of the wind assets. Scope exists to increase the generating capacity of the wind farm, while keeping the transmission infrastructure the same, for example: through installing 518MW of turbines with a 500MW electrical infrastructure. This helps minimise electrical costs, while maximising generation.

DNV GL has developed a model to aid this process in collaboration with DONG.

Serial production of jackets



There is significant scope to optimise the way in which jackets are designed and manufactured. The industry still tends to use a 'one-off' approach to manufacturing when a serial production approach would save cost.

DNV GL have identified that by reducing steel tonnage and tubular welds and by adopting more pre-fabrication, automated welding, mechanical handling and fit up techniques, jacket costs could be reduced by at least 25%.

DNV GL is working with fabricators to develop better jacket designs and manufacturing facilities.

DO IT DIFFERENTLY

INNOVATING FOR THE FUTURE

Use the FORCE



Project FORCE was an internally funded R&D project that shows integrated design of the turbine and support structure, combined with three near-market turbine technologies, could deliver significant LCoE savings (for large turbines in deep water).

Following on from the project, DNV GL is engaging with industry partners to form a small consortium to demonstrate the identified technologies on a real project.

Project FORCE showed significant cost reduction potential, with integrated design the key to unlocking it. Yet significant commercial barriers remain and our follow-on project 'Use the FORCE' is seeking to validate and demonstrate how the savings can be made on a real world project. It therefore will tackle the question of 'how' the industry can achieve these savings

Pushing the technical limits of turbines



Increasing turbine rotor diameter and rated capacity offers the single largest potential for cost reduction in offshore wind, through corresponding reductions in per MW balance of plant and operational costs as well as significantly higher capacity factors. Our Turbine Engineering team has supported the design of a range of offshore wind turbines up to 10MW capacity.

DNV GL is committed to continually to continually push the technological limits of turbine technology and contributing to the rapid upscaling of offshore turbines.

Commercialising Floating Wind



DNV GL is committed to assist in the commercialization of floating wind. After launching the world's first design standard for floating wind turbine structures in 2013, we are trying to create a market for floating turbines without subsidies. The ambition is to eliminate risks and technical barriers for using wind power to drive offshore oil & gas operations. We are identifying cases where it would be more cost effective to use wind than to retrofit old platforms with new gas turbines or where the gas supply is limited. Here wind power can be the most cost effective alternative if technical challenges are addressed.

DNV GL is launching a JIP called WIN WIN (WIND powered Water INjection) for the use of floating turbines for water injection for enhanced oil recovery. This JIP will start in December 2014 and will involve key offshore oil & gas operators, equipment manufacturers, relevant government agencies and wind turbine suppliers.

DNV GL

Driven by its purpose of safeguarding life, property and the environment, DNV GL enables organisations to advance the safety and sustainability of their business. DNV GL provides classification and technical assurance along with software and independent expert advisory services to the maritime, oil & gas and energy industries. It also provides certification services to customers across a wide range of industries. DNV GL, whose origins go back to 1864, operates globally in more than 100 countries with its 16,000 professionals dedicated to helping their customers make the world safer, smarter and greener.

ACKNOWLEDGEMENT:

DNV GL wishes to thank all our employees who made energetic and imaginative contributions to this manifesto.

"The secret is to gang up on the
problem, rather than each other."

Thomas Stallkamp



SAFER, SMARTER, GREENER