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Offshore proof
Turning windpower promise into performance

PwC offshore windpower survey – based on field research conducted by GBI

GBI Research
Global Business Intelligence

pwc

Contents

57 interviews were carried out with offshore windpower executives in 12 countries

Belgium
China
Denmark
Finland
Germany
Ireland
Japan
Netherlands
Norway
Spain
Sweden
United Kingdom

Methodology

PwC's offshore windpower survey is based on field research conducted between December 2010 and February 2011. In total, 57 interviews were carried out with offshore windpower executives in 12 countries by GBI Research. By country eight interviews were conducted in Germany, six in Denmark, six in Finland, six in the United Kingdom, five in Belgium, five in the Netherlands, five in Sweden, five in Spain, four in Ireland, four in Norway, four in China and three in Japan. Respondents were senior managers and executives from offshore windfarm developers and operators (13), utilities (10), contractor or turbine original equipment manufacturers (14), government bodies (8) and financial institutions involved in offshore windfarm finance (12). All interviews were conducted by telephone. Due to rounding, totals may not add up to 100% in some cases.

PwC thanks all the participants who took time to complete the survey. We would also like to thank our local PwC teams for their insightful contributions throughout this project.

Introduction

Offshore wind generation is fast growing and has great potential to meet energy needs in the future in a sustainable way. But many challenges – technical, financial and logistical – need to be overcome if this new energy source is to come of age and take its place as an enduring and significant part of the generation mix. The coming few years will be 'make or break' time in deciding whether offshore windpower will be able to get on track to prove its place as a source of large-scale generation. Ultimately, it needs to show it can reach efficiencies and cost levels near enough to onshore installations to make it competitive in the energy mix.

In 'Offshore Proof' we look at this and other challenges, getting the views of the major players who are central to determining the pace of growth of the industry. We speak to developers, contractors/original equipment manufacturers (OEMs), utility companies, government bodies and financial institutions. We gather industry data on the roll-out and performance of offshore wind generation so far. We discuss some of the main challenges that developers and contractors are facing. Finally, we look at the 'make or break' issues that will determine how quickly offshore wind will move from infancy to maturity.

The findings give cause for optimism while sounding a note of caution on the challenges that lie ahead. Emerging experience from European developers suggests that the foundations are in place for offshore technology to match or, if wind potential is realised, surpass onshore performance. But the need to reduce costs is immense and it remains unclear just how far cost reduction can go and when it will be achieved.

Manfred Wiegand
Global Utilities Leader

Paul Nillesen
European Renewable Energy Leader

Executive summary

The offshore wind industry is coming of age as it moves from a pioneering phase to one of large-scale industrial production. 'Offshore Proof' looks at some of the important challenges facing the industry with a survey of the views of some of the main players involved – developers, contractors/original equipment manufacturers (OEMs), utility companies, government bodies and financial institutions. Offshore windpower is furthest advanced in Europe so our survey focuses on European respondents, but is supplemented with a small number of interviews in Asia, where offshore windpower projects are beginning to be developed.

The prospects for offshore windpower look bright, according to many of the government respondents to our survey. Three-quarters are reasonably confident that it will play an enduring part in the energy mix in the coming 20 years and three-fifths expect it to be economic without subsidies within 15 years.

Much is expected of offshore windpower. Three-quarters of the survey respondents from government bodies anticipate it will play an enduring role in the energy mix in the coming 20 years and nearly three-fifths (59%) expect it to be economic without subsidies within 15 years. But doubts remain about whether technological developments will work in favour or against offshore wind generation. Although over three-fifths of the government bodies we surveyed think there is a medium to high chance of technological breakthroughs boosting offshore windpower, the same proportion also acknowledge it could get overtaken by breakthroughs in other renewable technologies.

An important challenge facing the industry will be to show that onshore turbine performance can be matched by offshore performance. Survey results from European developers give some cause for optimism. Offshore wind projects are achieving comparable levels of availability to onshore. Fewer than one in five reported downtime being a greater problem than they had expected, with the remainder saying downtime matched their pre-project expectations.

The biggest challenge facing the industry is to bring costs down to a range where offshore windpower can compete in the energy mix with little or no subsidy. But the outlook among contractors/OEMs for cost reductions is mixed. The greatest expectation is of a cost decrease in real terms (42% of respondents) but many do not foresee any reduction and, indeed, a quarter actually forecast cost increases.

All of the European developers in our survey reported capacity availability rates in the 90%-97% range. But availability needs to be matched by good wind conditions and, while some respondents claim that their wind projections are achievable, there has been concern about recent low wind conditions in the North Sea, particularly in the winter of 2009/10.

The biggest challenge facing the industry is to bring costs down to a range where offshore windpower can compete in the energy mix with little or no subsidy. How far costs need to fall will partly be driven by fossil fuel and carbon prices, but also by consumer sentiment towards paying continuing subsidies. Will greater scale and technological maturity translate into cost reductions? The outlook among European contractors/OEMs on construction and turbine costs is positive but mixed. The greatest expectation (42% of contractor/OEM respondents) is of a real-terms cost decrease but many do not foresee any reduction and, indeed, a quarter actually forecast cost increases.

We also report on a number of other 'make or break' issues. Construction and technological risk is a significant barrier to investment. But we found that the risk perception of offshore windpower is improving in the minds of the European financial institutions we surveyed. Nearly two-thirds said offshore windpower investment risk was reducing and only a small percentage (9%) thought that risks had increased in the past two years.

Supply chain management is a major challenge. Nearly all of the developers said supply chain capacity constraints are a significant problem for offshore wind construction to such an extent that 82% said they create the risk of a seller's market. A majority saw supply chain risks as likely to increase in the future. But few thought it would be harder for them to manage future supply chain risks and two-thirds were satisfied with how they had managed such risks so far.

We tested investor sentiment towards offshore windpower compared to other forms of clean energy investment. Onshore wind generation is favoured over offshore generation and biomass/biogas is viewed in particularly favourable terms. In contrast, solar power is viewed less favourably, reflecting its immaturity as a source of utility-scale generation. In a question asked before the earthquake and nuclear emergency in Japan, the investment potential of nuclear was favoured over offshore windpower. But in a follow-up question asked six weeks after the earthquake, three-quarters of the same respondents said their investment sentiment had shifted negatively against nuclear. Of course, the exact long-term impact of the events at the Fukushima nuclear power plant is still uncertain.

The need for greater certainty and agreement between the industry and governments is illustrated by a mismatch between industry and government body perceptions of subsidy arrangements. Ninety per cent of the European utility company survey respondents said discussions between the industry and governments about financing and subsidy mechanisms still needed improvement. No government body respondents were of the same point of view. Set against this, there is considerable consensus on matters such as the need to improve grid access and transmission capacity.

Bottlenecks and supply chain constraints mean supply chain management is a major challenge facing developers. Nearly all of the developers we surveyed said supply chain capacity constraints are a significant problem for offshore wind construction to such an extent that 82% said they create the risk of a seller's market.

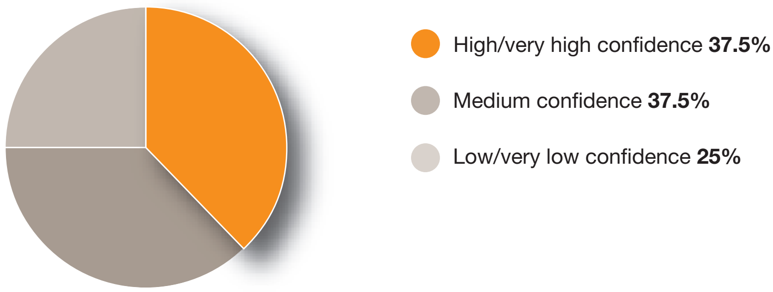
Offshore windpower risk perceptions are improving. Nearly two-thirds of the European financial institutions we surveyed say offshore windpower investment risk has reduced in the past two years. Only a small percentage (9%) thought that the risks had increased.

Promise, performance and costs

Promise

Offshore windpower is expected to play a growing role in power generation. In 2009, worldwide offshore wind capacity was 2.9 GW. By 2035, the International Energy Agency (IEA) forecasts that it will have reached a minimum of 115 GW, but more likely 180 GW or as much as 340 GW if policy-makers step up their renewables policies[1]. In Europe, for example, the EU and European Wind Energy Association (EWEA) have established aggressive targets to install 40 GW of offshore windpower capacity by 2020 and 150 GW by 2030. The US has an ambition to develop 54 GW of offshore wind generating capacity by 2030[2].

Figure 1: Government confidence in offshore windpower is proving to be an enduring part of the energy mix for the next 20 years or more



Current capacity is concentrated in Europe, predominantly in the North Sea with the UK, Denmark and the Netherlands among the early installers. Germany and Norway followed suit in 2009. In the same year, China became the first country in Asia to invest in offshore wind while Japan has invested in some near-shore installations.

Offshore locations enable large-scale generation well away from the problems with site, planning and public acceptance that limit onshore windpower, but with increasing installation problems as projects move into deeper water. The installed capacity in Europe is expected to grow by a staggering 28% per annum on average, with Europe continuing to lead the way in offshore windpower worldwide.

The government bodies that we spoke to in our survey are putting considerable faith in offshore windpower developing in a manner that enables it to take its place alongside other established forms of generation. Three-quarters have a medium or high level of confidence that it will prove itself and be an enduring part of the energy mix in future decades (figure 1).

But the growth of offshore windpower is reliant on such generation becoming more competitive. The presumption is that scale and learning will reduce cost. For example, the IEA's forecasts assume that offshore wind generation costs will nearly halve by 2020-2035 from their average in 2010-2020. If this happens, it will bring such costs more into line with onshore wind.

[1] International Energy Agency, 'World Energy Outlook 2010'.
[2] US Department of Energy, 'A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States', February 2011.

At present, offshore wind development relies on government subsidy. Subsidy policies, as well as being a means of delivering carbon reduction targets, are viewed by governments as a foundation on which offshore wind generation can grow to a point where it can develop without subsidy. Three-quarters of the government respondents to our survey expect that this will happen within a 10-20 year timetable, with the majority of these anticipating that offshore windpower will be economic in the marketplace within 15 years. Nearly a fifth (17%) are more optimistic, pointing to a timetable of ten or fewer years (figure 2).

But these expectations are far from certain. A major uncertainty is technological change. Breakthroughs in technology could support offshore windpower growth or, possibly, undermine it, if rival renewable technologies prove to be more sustainable. Our government respondents expect technological breakthroughs to be more likely to work in favour than against offshore windpower (figure 3).

Over a third believe there is a high or very high chance of technological breakthroughs supporting its development. None gave such high ratings to the chance of offshore windpower being overtaken by breakthroughs in other renewable technologies that will undermine its part in the energy mix in the next 20 years. But over three-fifths sound a cautious note – saying that there is a medium chance of offshore wind being eclipsed by other technologies.

Figure 2: In what timeframe do governments expect offshore windpower to become economic without subsidies?

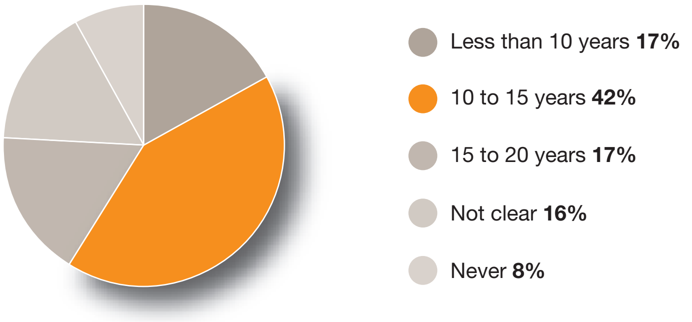
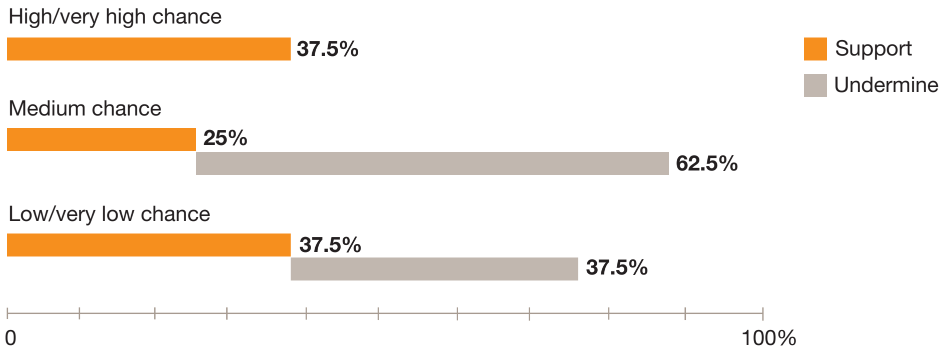


Figure 3: Technological uncertainty – will technological breakthroughs support or undermine offshore windpower in the energy mix over the next 20 years? (Government respondents)



Turning or rusting?

Technological change can alter the landscape dramatically. Thirty years ago few knew about the potential of the internet or predicted the decline of traditional mail. In another 30 years' time, will offshore wind turbines be mainstay major energy sources? Or could they be rusting relics?

Where will technological breakthroughs take us? Nearly two-thirds of government respondents think technological breakthroughs will spur offshore windpower. But the same proportion see a chance that offshore wind will be overtaken by breakthroughs in other renewable technologies in the next 20 years.

Performance

Offshore locations offer better wind potential than onshore locations. In Europe, offshore load factors are typically in excess of 35% in contrast to the 25-30% achieved by onshore wind generation. But technical challenges mean that offshore turbine performance can be worse than onshore. Failure rates can be higher, and failures are more difficult and expensive to fix, reducing turbine availability. Companies are moving along a learning curve in adapting and developing onshore technology to meet the different demands of an offshore environment.

Figure 4: Are developers finding downtime greater or less than expected? (Europe)

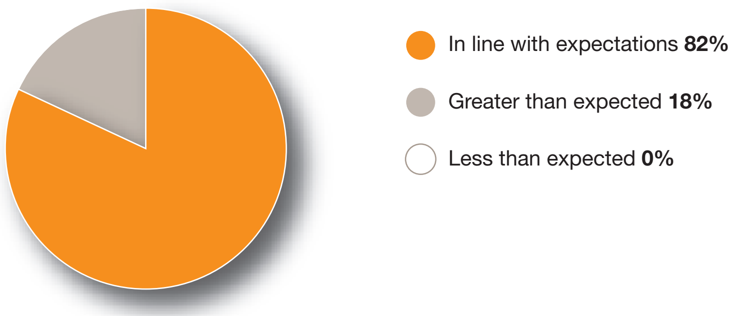
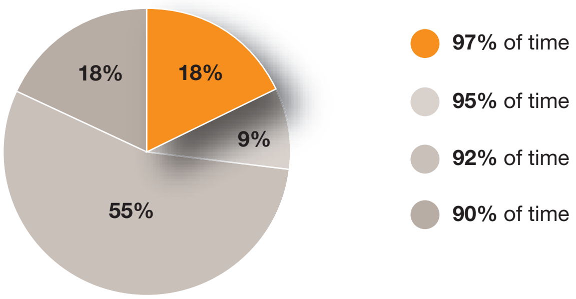


Figure 5: What capacity availability rates (% of time) are developers reporting in Europe?



These technical considerations can have a significant impact on performance. We asked developers to report on their performance experience to date. Their responses suggest that the early offshore windpower projects are getting off to a promising start from the point of view of downtime and turbine availability.

Fewer than one in five (18%) of the European developers reported downtime being a greater problem than they had expected, with the remainder saying downtime matched their pre-project expectations (figure 4). In contrast, in Asia, we spoke with one Japanese developer which reported downtime to be less than it had anticipated, but this was in the context of a well established nearshore rather than far offshore installation.

Most importantly, this confidence in performance is reflected in availability rates. All of the European developers in our survey reported capacity availability rates in the 90%-97% range. Fifty-five per cent reported a 92% rate and 9% reported 95%. The remainder were evenly split between 90% and 97% (figure 5). The remaining critical variable is actual wind conditions. There has been concern about recent low wind conditions in the North Sea, particularly in the winter of 2009/10, but survey respondents were still confident about achieving projected wind profiles.

Developers report that this early operational performance is translating into a robust return on investment. The survey gathered data on matters such as internal rates of return (IRRs) and other measures of offshore wind investment value. Developers report post tax IRRs typically in the 10-15% range. This was the case for 82% of the European developers. None of the developers said that post-tax returns were turning out lower than expected. Instead, all reported them to be on course and, indeed, nearly a fifth (18%) said they were higher than expected.

If the IRR exceeds the weighted average cost of capital (WACC), the projects have a positive economic return. The WACC may differ between projects and countries due to differences in the risk profile. In general the WACC for wind projects is relatively low as the project returns are stable due to the subsidy schemes. In European markets the WACC of developed offshore projects is closer to 10% than to 15%. This suggests that the IRR of the majority of offshore wind projects exceeds the WACC and that the projects are economically profitable.

Offshore windpower dialogue: Reducing costs

Cost reduction is critical if offshore wind is to become economic without subsidies. But how can costs be brought down?

Classic ways to bring down costs are to focus on scale and scope. Scale allows players to benefit from standardisation, bulk purchasing and learning effects. Scope, on the other hand, allows companies to benefit from using fixed investments for more than one purpose.

In the case of offshore windpower, where scaling up is currently underway, other ways to reduce or manage costs can come from more effective allocation of risks between parties. Here governments can play a critical role, such as by taking away risks associated with permitting. Another way to reduce costs is through greater cooperation, for example by enabling the sharing of certain facilities that all parties need, such as harbour facilities.

Costs

Cost is the most significant factor holding back offshore wind development. High capital costs arise because turbines need to be capable of withstanding hostile operating conditions at sea and there are increased costs related to turbine foundations, balance-of-system infrastructure, interconnection and installation. In addition, there are the costs of the facilities needed for manufacturing and transportation, such as port infrastructure, vessels and assembly facilities. Financing costs are also higher because of the increased risk perceived by investors and lower gearing possibilities.

A study commissioned by the UK government, taking account of upfront capital costs and ongoing operating and maintenance (O&M) costs, estimated the levelised cost of offshore wind generation was £144 per MWh in 2009. This compared with the study's assumed long-term estimate of £60/MWh for future wholesale power[3]. The gap has to be met by subsidies. A 2011 US Department of Energy study reached similar conclusions, estimating that offshore windpower's 'cost of energy' projections would need to be cut by more than 50% for the country's offshore wind strategy to be realisable (see panel).

In our survey, around half of developers report that high capex is a 'significant' or a 'major' problem for their projects, causing delays or bottlenecks as funding difficulties are overcome. Among the financial institutions that participated, the high investment cost is characterised as a 'high risk' by nearly three-fifths of respondents (58%).

Construction costs account for a large proportion of capex. The exact proportion varies according to the exact project circumstances and is influenced by factors such as water depth, distance to the shore and grid connection works. There is significant variation in the construction costs reported by our survey respondents. One in three of the developer and contractor/OEM respondents said that construction costs accounted for more than 40% of total capex in recent projects, while over half (55%) said that they were less than a quarter of total capex.

Reducing the cost of offshore windpower

The US Department of Energy's National Offshore Wind Strategy[4] estimates the 'cost of energy' from offshore wind generation. In general terms, the 'cost of energy' is the sum of all up-front annualised capital equipment costs and operating and maintenance costs over the life of the project, divided by the total energy output of the project.

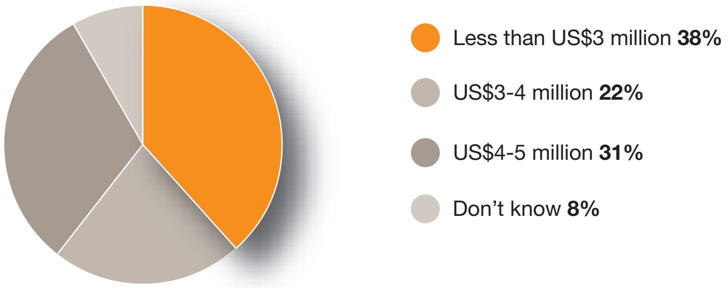
The strategy estimated the 2010 'cost of energy' from offshore windpower as US$270/MWh. It envisages this falling to US$100/MWh by 2020 and US$70/MWh by 2030. These cost reductions come from (1) increased system efficiency and decreased capital costs as larger, more integrated and innovative systems are rolled out; (2) reduced operational and replacement costs through higher reliability and innovative, low-maintenance designs; and (3) reduced financing costs, with the discount rate declining from a current estimate of 20% to a target level of 8% by reducing perceived risks to investors.

[3] UK Department of Energy and Climate Change, 'Cost of and financial support for offshore wind', April 2009.
[4] US Department of Energy, 'A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States', February 2011.

Over half of European contractors/OEMs (53%) reported average construction costs in the US$3-5m/MW range, although more than a third (38%) estimated per MW construction costs to be less than US$3m (figure 6). We also spoke to four contractors/OEMs in Asia. Again there was significant variation, reflecting project circumstances. They estimate average construction costs broadly in line with those in Europe – two in the US$3-4m/MW range but also with one less than US$3m and one over US$5m/MW.

Control of capital expenditure is critical for offshore power projects. Not only is there already a gap between their costs and market sustainability, making them reliant on subsidy, but there is little opportunity to recover cost overruns through adjusted operational returns given the nature of the subsidy mechanisms. The only big outside variable comes from wind conditions but these are beyond anyone's control. Thus, capex increases can have a very damaging effect on capital returns.

Figure 6: What are the average construction costs per MW in the most recent projects? (European developers and contractors/OEMs)



Offshore windpower dialogue: Avoiding a 'sellers' market' in the supply chain

Three-quarters of developers said supply chain constraints create the risk of a seller's market. How can this be avoided? How can developers maintain control and the balance of power in their relationship with suppliers?

As the offshore wind market develops, it is unavoidable that imbalances will occur in the market between suppliers and developers. As the market matures, new entrants will lead to a rebalancing of power. In the short term, a number of players have invested in the value chain themselves, for example by purchasing the necessary vessels to transport equipment or by signing long term partnership contracts with suppliers.

For larger players with the ambition and balance sheets to play a major role in offshore windpower this is easier to achieve than for smaller, one-off players. The latter group will need to seek alliances with others and collaborate, rather than compete, to provide the right counterbalance. There is also a potential role for governments by reducing or removing barriers to entry in the value chain.

European developers and contractor/OEMs have the most offshore wind project experience and the majority of them reported that construction costs of recent projects were in line with budget expectations. But a quarter (26%) said construction costs had turned out above budget (figure 7). In Asia, offshore wind is more in its infancy. We spoke with four developers and contractors/OEMs and three of the four reported cost overruns.

There was significant variation in project O&M costs reported by developers. A third of European contractors/OEMs put these in the US$14-28/MWh range or lower but developers said they were higher, with 55% putting them in the US$28-42/MWh range. A further 27% of European developers said they were over US$50/MWh. But, although the reported level varied, European developers said that their O&M costs were in line with their budget expectations (figure 8).

Figure 7: Was there a difference between actual construction cost and the budget? (European developers and contractors/OEMs)

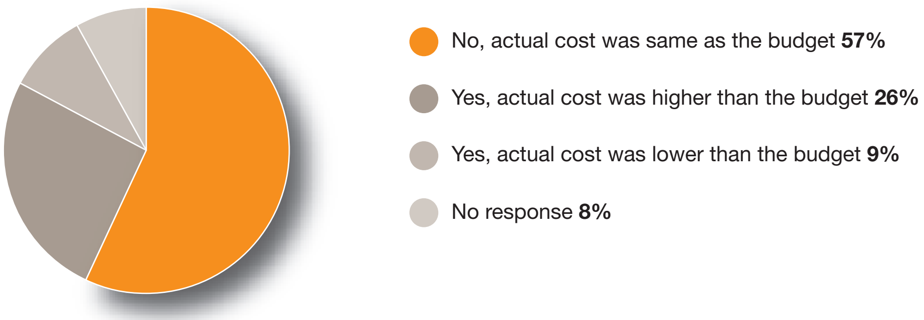
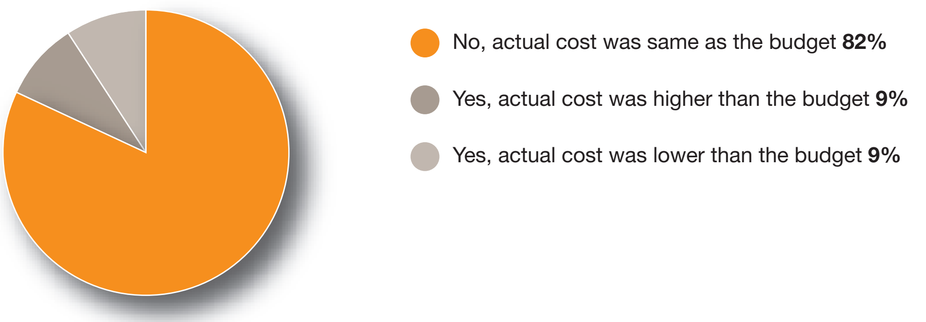


Figure 8: Was there a difference between actual O&M cost and the budget? (European developers)



Offshore windpower in Asia

Offshore windpower installations in the Asia-Pacific region are currently confined to China and Japan. China commissioned the 102 MW Shanghai Donghai Bridge windfarm in 2009, taking its cumulative installed capacity to 109.5 MW. China's National Energy Bureau says it intends to start construction on 1,200 MW of offshore windpower projects. Some observers expect China to have installed 30,000 MW of offshore capacity by 2020.

While Chinese projects are expected to form a major part of offshore windpower growth in the region, developments in Japan and South Korea are also significant. Japan is the only other country in Asia with offshore windpower currently being produced. There are three offshore windpower sites with a total of 14 turbines with a total capacity of 25.2 MW (Sakata (2 MWx5), Kamisu(2 MWx7) and Setana (0.6 MWx2)).

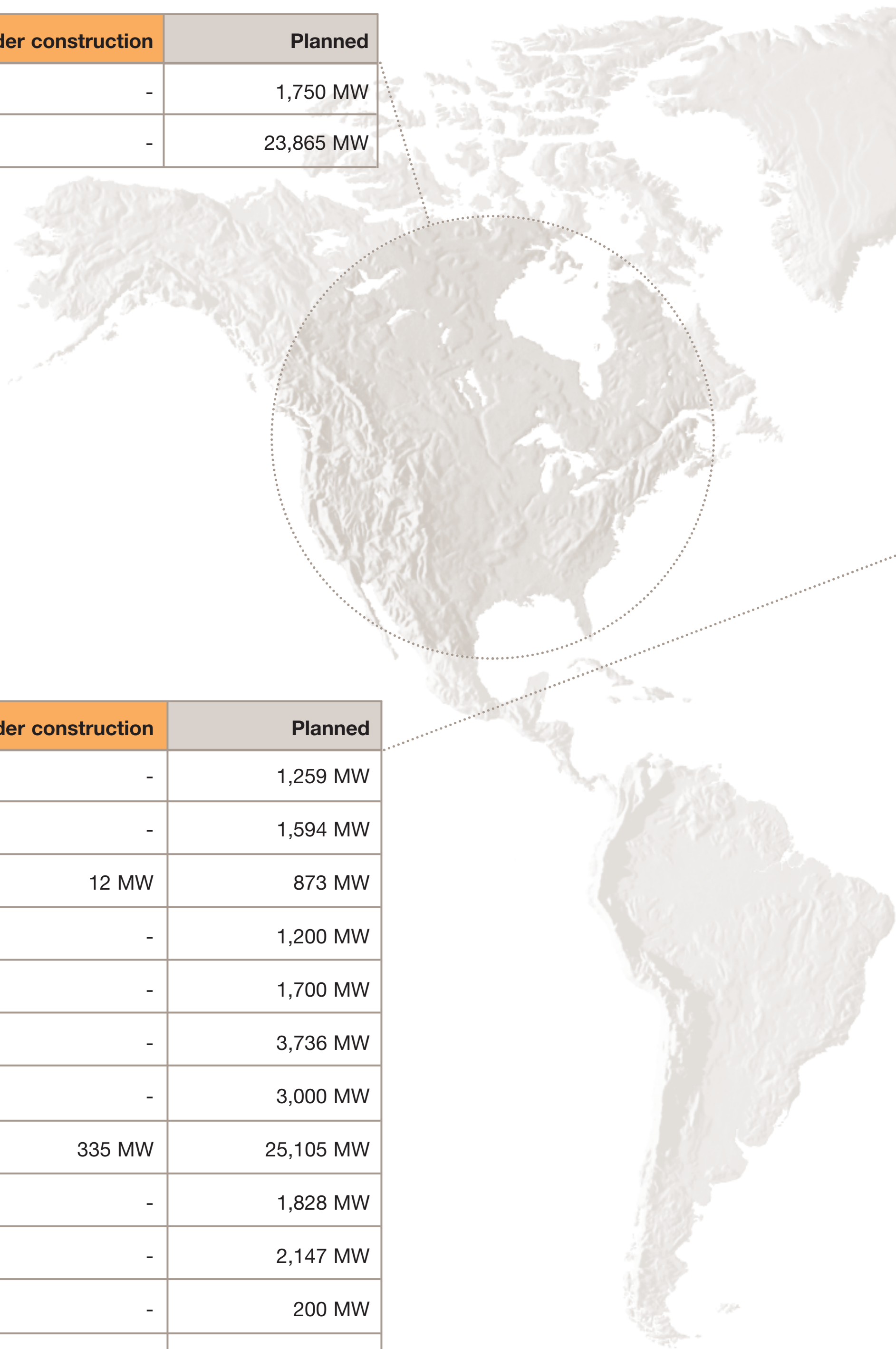
In May 2010, the Tokyo Electric Power Company announced plans to run a 2 MW test plant in Chiba. There were no reports of damage to existing installations after the 2011 earthquake and events following that tragedy may spur further offshore windpower expansion. South Korea is focusing offshore for its windpower growth as it has unfavourable conditions for onshore development. It is aiming for nearly 4,000 MW of offshore windpower capacity by 2020.

Our survey included a small number of respondents from China and Japan. Their responses provide a snapshot rather than a survey and mirror many of the same concerns expressed in our Europe survey. One financier we spoke to, for example, highlighted the high degree of technological operating and maintenance risk that will be associated with offshore windpower and, perhaps reflecting the less mature stage of evolution compared with Europe, said that offshore windpower risk had increased rather than decreased in recent years.

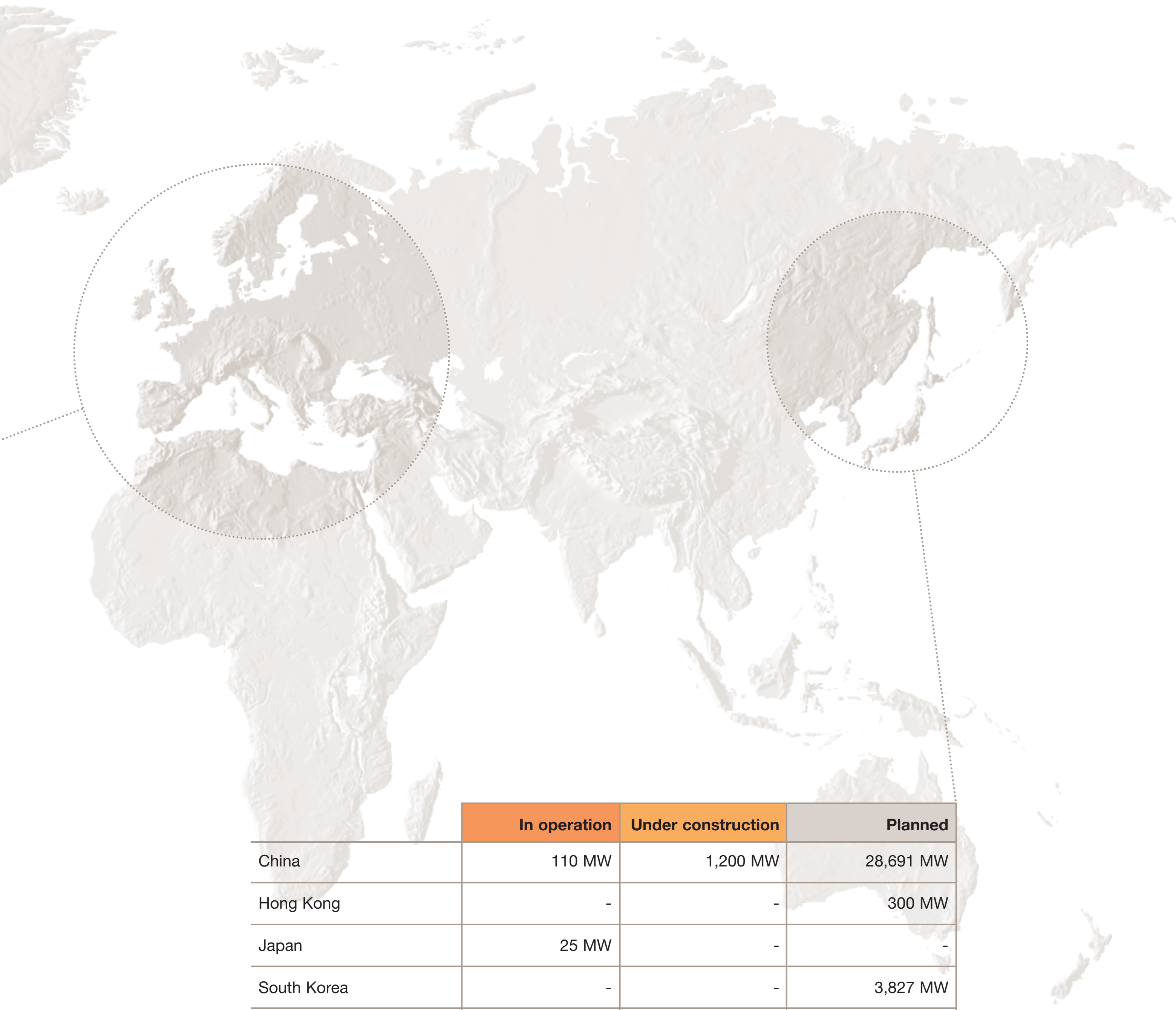
Again reflecting the later development of the sector, the Chinese and Asian developers we spoke with were less concerned about existing supply chain bottlenecks than their European counterparts. But they were inclined to recognise that such constraints were likely to occur in the future as expansion gathers pace. Also, three of the four developers and contractors/OEMs that we spoke with reported project cost overruns (see pp 11-12).

Global overview of offshore windfarms in operation, under construction and planned (in MW)
Source: GBI Research, PwC analysis (data gathered April 2011)

	In operation	Under construction	Planned
Canada	-	-	1,750 MW
United States	-	-	23,865 MW



	In operation	Under construction	Planned
Albania	-	-	1,259 MW
Belgium	195 MW	-	1,594 MW
Denmark	876 MW	12 MW	873 MW
Egypt	-	-	1,200 MW
Estonia	-	-	1,700 MW
Finland	30 MW	-	3,736 MW
France	-	-	3,000 MW
Germany	185 MW	335 MW	25,105 MW
Ireland	25 MW	-	1,828 MW
Italy	1 MW	-	2,147 MW
Malta	-	-	200 MW
Netherlands	247 MW	-	5,423 MW
Norway	2.3 MW	-	10,435 MW
Poland	-	-	299 MW
Romania	-	-	500 MW
Spain	10 MW	-	500 MW
Sweden	163 MW	-	2,857 MW
United Kingdom	1,341 MW	2,238 MW	43,652 MW



	In operation	Under construction	Planned
China	110 MW	1,200 MW	28,691 MW
Hong Kong	-	-	300 MW
Japan	25 MW	-	-
South Korea	-	-	3,827 MW
Taiwan	-	-	600 MW

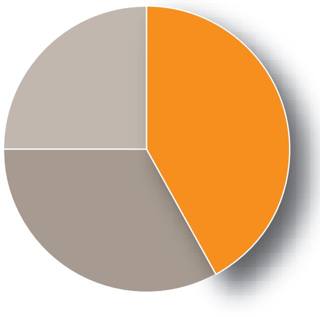
Make or break issues

The big 'make or break' issue for the offshore wind sector is the extent to which it will be successful in getting its cost base down. Its survival and growth will depend on the long-term cost outlook. The industry is in a classic 'chicken and egg' situation. To get the cost base down it needs economies of scale. To get economies of scale it needs to make a convincing case that costs can come down. We asked our survey respondents about the big issue of cost and a range of other 'make or break' issues.

Cost reduction

Cost reduction is critical if offshore wind is to become economic without subsidies. How can costs be brought down and what is the cost outlook among our survey respondents? Scale and smarter technological and engineering solutions are the main routes. Scale is being achieved by larger turbine size as well as larger windfarms.

Figure 9: What is your forecast for construction costs and turbine prices in the next five years? (European contractors/OEMs)



Four-fifths (79%) of European developers and contractors/OEMs in our survey reported turbine sizes in the 3-5 MW range. But plans for larger capacities of 6 MW or above are becoming more common. One in six of the European survey respondents reported plans for turbine sizes of 5-6 MW or above. Plans for turbine sizes in Asia were smaller – with some below 3 MW and others of 4-5 MW capacity – reflecting the less mature development of offshore wind in that continent.

But will increases in turbine and overall project size translate into decreases in cost? Figure 9 shows the views of contractors and OEMs. We have reported the European results only, as the sample for Asian contractors/OEMs was too small to give meaningful results. The outlook among European contractors/OEMs is mixed. The greatest expectation is of a real-terms cost decrease (42% of respondents) but many do not foresee any reduction and, indeed, 25% forecast real-terms cost increases.

Interestingly, of those forecasting real-terms cost changes, either upward or downward, most thought that such changes would be quite significant. Offered a range of 0-10% or 10-20%, four-fifths (80%) of those forecasting decreases said that it was likely to be in the 10-20% range, with the remaining fifth opting for a 0-10% decrease. Similarly, half of those forecasting cost increases chose the higher 10-20% range.

Significantly, also, there is a reasonably strong sentiment among contractors and OEMs that the potential for cost reduction is fairly strong across a number of cost centres (figure 10). Not surprisingly, turbine technology stands out as offering the greatest cost reduction potential but a clear majority also pointed to repairs, overheads, grid connection, materials and transportation costs as offering significant potential for lower costs in the future.

Another major opportunity for cost reduction is in offshore turbine foundations. The monopile design in current use accounts for about a quarter of the total investment cost of an offshore windfarm. The trend is towards floating or gravity foundation design, adapted from the offshore oil and gas industry. Such designs allow much of the construction to take place onshore with potential for reduced cost and they enable installation in deeper water conditions.

Looking along the cost curve

In the space of just ten years to 2008, the cost of purchasing a motor vehicle fell in real terms by 39%[5]. In recent years, the price of many electronic goods has shrunk even more dramatically. For example, audio-visual equipment prices in 2004 were less than a quarter of their level in 1987[6]. But can the cost of offshore windpower halve, which is the magnitude of cost reduction needed for it to be fully competitive in the energy mix?

It is possible to envisage design and technological innovation reducing some aspects of cost significantly. But, unlike the dramatic reductions in small component electronics, much of the cost of offshore windpower comes from heavy engineering, steel and other raw materials inputs. Trends in commodity prices make it difficult to envisage major cost savings for these elements. The jury is still out on just how far the offshore windpower cost curve can move downward.

Figure 10: What areas offer the biggest potential for the most realistic future construction and O&M cost reductions? (Contractors/OEMs)

	'Medium' potential	'Strong' or 'very strong' potential	**Total**
Turbine technology improvement	57%	36%	**93%**
Reduced repair costs	43%	36%	**79%**
Reduced overhead costs	43%	21%	**64%**
Reduced grid connection costs	21%	43%	**64%**
Reduced materials costs	36%	28%	**64%**
Reduced transportation costs	43%	21%	**64%**
Reduced logistics costs	29%	28%	**57%**
Reduced land costs	29%	21%	**50%**
Reduced labour costs	29%	14%	**43%**
Reduced administration costs	29%	7%	**36%**

[5] UK Office for National Statistics, 'Social Trends 2010', p177.
[6] UK Office for National Statistics, 'Economic Trends 626', January 2006.

Construction risk and financing

As we discussed in the 'promise, performance and cost' chapter, the construction phase is critical for offshore wind projects. It is the point at which the project economics are won or lost. Delays or cost overruns in construction can fundamentally alter the project economics. When a project becomes operational, the options for creating upside returns are restricted to outperformance on expected operating costs.

For this reason, financial institutions and other investors look very cautiously at construction risk. Stand-alone financing, with banks taking the construction risk, were possible in Europe in 2006 and 2007. But the credit crisis resulted in the withdrawal of many lenders from project finance and reduced appetite from others. There is now an increased involvement of public funding institutions such as the European Investment Bank.

As more projects reach completion and construction experience grows, there are signs that financiers are becoming more comfortable with offshore windpower lending. Indeed, of four main risks presented to financial institutions in our survey, construction risk, while very significant, was rated much lower than worries about government subsidies and technology/O&M risks (figure 11).

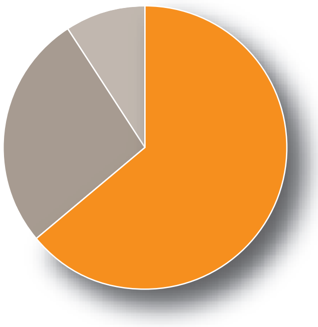
In part, this reflects the history of projects that they have knowledge of – for some, the construction phase is completed but potential O&M and technology performance hazards still lie ahead. It also reflects uncertainty arising from government reviews of subsidy regimes. In the UK, there is a review of Electricity Market Reform (EMR) and the renewables obligation certificate (ROC) banding review. In the background, reviews of other renewables subsidy regimes have cut solar feed-in tariffs in countries such as France, Italy and Spain. These developments have added to uncertainty about government subsidy arrangements.

Despite continuing review of the regulatory background, the risk perception of offshore windpower is improving in the minds of the financial institutions that we surveyed in Europe. Only a small percentage (9%) thought that risks were increasing. Instead, nearly two-thirds (64%) said they were reducing, with the rest (27%) saying that the risks had stayed the same (figure 12).

Figure 11: What do financial institutions see as the main risks associated with funding offshore windparks? (Europe)

	Low or no risk	Medium risk	High risk
Technology/O&M risk	9%	18%	73%
Uncertainty in cash flow due to changing government subsidies	0%	36%	64%
Uncertainty in cash flow due to high investment	9%	36%	55%
Construction risk	18%	45%	36%

Figure 12: Do financial institutions think offshore windpower risks have got better or worse in the last two years? (Europe)



Supply chain management

The complexity of offshore windpower projects means that the market for turnkey contracts, where a contractor takes the construction risk, has been slow to develop. Instead, multi-contracting with three to four suppliers of key work packages is a more common arrangement. Or, in some cases, developers seek to manage the whole supply chain themselves rather than bundle it into packages.

Such arrangements inevitably heighten supply chain management demands. In turn, these demands are more complex in an environment such as offshore windpower where project experience is relatively low and the learning curve is very steep. Particularly in Europe, bottlenecks along the key parts of the supply chain, such as vessel availability, port infrastructure and engineering availability, have negatively affected projects.

Nearly all (91%) of the developers we surveyed said supply chain capacity constraints are a significant problem for offshore wind construction to such an extent that 82% said they create the risk of a seller's market (figure 13). Fifty-five per cent of developers saw supply chain risks as likely to increase in the future. But few thought it would be harder for them to manage future supply chain risks and two-thirds (64%) were satisfied with how they had managed such risks so far.

Figure 13: Developers' views on supply chain constraints and management of supply chain risk (Europe)

	Agree	Disagree	Neither agree or disagree
Supply chain capacity constraints are a significant problem for offshore wind construction	91%	0%	9%
Supply chain capacity constraints in offshore wind construction create the risk of a 'seller's market'	82%	9%	9%
My company has been able to manage risk and mitigate supply chain constraints so far	64%	0%	36%
Such risks are likely to intensify in the future	55%	9%	36%
It will become harder to manage the risk arising from future supply chain constraints	9%	64%	27%

While companies seem confident about managing supply chain risk, it appears high on the list of key things they would seek to change in future projects as a result of learning on projects so far (figure 14). Correctly setting up, managing and controlling the supply chain is one of the key success factors for projects. The type of procurement approach is an important factor in whether a project delivery turns out to be successful or not.

In the best case it protects project value but, in the worst case, it can destroy value. Once the procurement stage is passed, owners start losing flexibility on how to create and retain value. They have locked in the delivery of the business case and are in the hands of the supply chain.

Figure 14: With the experience obtained from previous projects, what would be the main changes in new projects? (European developers and contractors/OEMs)

	'Significant' or 'major' change	'No change' or 'minor' change
Type of regulatory support	66%	34%
Location selection	66%	34%
Supply chain management	65%	35%
Type of turbine	61%	39%
Environment analysis	48%	52%
Raw materials procurement	35%	65%

Grid access

Grid access is one of the biggest issues facing offshore wind development in Europe. There are two aspects to the issue. First, projects need to be connected to the grid. Different countries take different approaches to this. For example, in contrast to the UK market, the grid operator in Germany is obliged to connect the projects to the electricity grid and to bear the cost.

But, even if projects are connected to the grid, power has to be transported to the consumer. In Germany, the majority of consumers are located in the middle or in the south of the country, and not near the coast in the north. At present, a timetable of 10-15 years for a grid connection from one part of the country to another is not unusual. This could prove a major stumbling block for the expansion of offshore windpower.

Grid systems also have to be smarter to respond to the variability in wind output. Much will depend on progress towards the creation of a North Sea supergrid, along the lines proposed by the European Wind Energy Association and a working group in the European Commission's energy department[7].

The importance of improved grid access was emphasised by our survey respondents. For example, all of the European government respondents said that improved grid access was necessary, with 80% saying it would make a 'strong' or 'very strong' impact on offshore windpower development. Investment in transmission infrastructure was seen as being most important with, again, 80% saying it would make a 'strong' or 'very strong' impact.

Such views are reflected in the responses of power utility companies themselves. They emphasised the importance of better government policy on grid access. Nearly all (90%) of the European utility company respondents we interviewed said that government policies on offshore windpower offtake and laying grid lines needed improvement, with 30% saying they needed a lot of improvement.

[7] Georg Wilhelm Adamowitsch, European Coordinator's Third Annual Report, 'Projects of European Interest, Connection to offshore windpower in Northern Europe (North Sea – Baltic Sea)', Dec 2009-Oct 2010.

European power utility company respondents also stressed the importance of stronger directives and financial support for new grid lines (figure 15). The importance of a supergrid comes as much from recognition of its importance in making more efficient use of a diverse range of generation sources, through better pooling and management of spinning reserves, as from its importance for optimal integration of windpower (figure 16).

Figure 15: In the minds of European power utility companies, what areas need the greatest improvement if governments are to improve offshore wind grid access?

	Needs 'a lot of improvement'	Needs 'some improvement'
Mandating utilities to lay grid lines	40%	50%
Financial support for laying grid lines	30%	50%
Transmission infrastructure investment	30%	40%
Implementation of smart grid technology	10%	70%
Encouragement of public private partnerships	10%	30%
Investment in advanced technologies to reduce transmission losses	0%	70%

Figure 16: What do power utility companies believe are the most important reasons for a European supergrid and how much improvement is needed?

	Needs 'a lot of improvement'	Needs 'some improvement'	It is already satisfactory or good
To pool load variability and power station unreliability	50%	20%	30%
To reduce the margin of inefficient spinning reserve and standby that have to be supplied	20%	70%	10%
To lower the cost of power in all participating countries by allowing the entire region to share the most efficient power plants	0%	70%	30%
To allow for much wider use of renewable energy, particularly windpower	0%	60%	40%

Investment attractiveness

Considerable investment needs to be attracted into the offshore wind sector if expansion plans are to be realised. The IEA 'current policies' scenario estimates a minimum of US$260bn offshore windpower investment is needed worldwide between 2010 and 2035, rising to US$400bn or as much as US$640bn if the policy stance of governments shifts further towards renewables[8]. In Europe, data from NLD Taskforce Offshore Wind Energy indicates that an additional 40 GW of offshore wind energy will require finance of €150bn in the period to 2020 with a financing gap of €95bn[9].

As we discussed under 'construction risk and financing' earlier in this chapter, financial institutions perceive the construction stage of offshore wind projects to be inherently risky. They are also concerned about technology risk, with the ongoing performance of turbine technology yet to be fully proven in offshore environments. In the renewables field, offshore wind generation has to compete for capital with other technologies such as onshore windpower and solar technology. In terms of cleaner energy, offshore wind is in competition with nuclear power for investment and also with expansion of gas as a replacement for coal-fired generation.

We asked the European financial institutions in our survey for their perceptions of the relative attractiveness of offshore windpower investment compared with some of these other energy sectors (figure 17). The survey was conducted before the nuclear emergency that unfolded after the earthquake in Japan. The striking result was how far the investment potential of nuclear was favoured over offshore windpower in the minds of the survey respondents.

Clearly, in the policy context that prevailed before the events at the stricken Fukushima plant, nuclear was seen as a mature, proven technology offering market expansion potential compared to the relatively unproven offshore wind generation technology. But in a follow-up question asked six weeks after the earthquake, three-quarters of the same respondents said their investment sentiment had shifted negatively against nuclear.

Turning to other generation sources, hydro is also mature and proven but is not seen as attractive because of its limited expansion potential. Onshore wind is favoured over offshore generation and biomass/biogas is viewed in particularly favourable terms. In contrast, solar power is viewed less favourably, perhaps reflecting its immaturity as a source of utility-scale generation and concern about recent regulatory changes.

A nuclear wind of change

Even before the Japan nuclear emergency, a trend of nuclear companies extending their low carbon offering through purchases of windpower and other renewables companies was already evident. US and French nuclear power generators and engineering firms have bought into the wind and solar sectors.

Many of these moves by nuclear companies are driven by diversification. The reaction to the Japanese nuclear situation has been to take stock. Whatever the exact outcome, the Fukushima emergency is likely to shift the energy policy balance towards renewables. While it won't raise a red flag to investment in nuclear, it could spur further moves by nuclear companies into renewables.

[8] International Energy Agency, 'World Energy Outlook 2010'.
[9] Ecofys, Fraunhofer ISI, TU Vienna EEG and Ernst & Young, 'Financing Renewable Energy in the European Energy Market', January 2011.

Figure 17: How do European financial institutions rate the investment potential of offshore windpower relative to other energy sectors?

	Offshore is less or much less attractive	Offshore is neither more nor less attractive	Offshore is more or much more attractive
Thermal	27%	45%	27%
Hydro	27%	27%	45%
Nuclear	55%	36%	9%
Onshore wind	36%	45%	18%
Solar power	27%	18%	55%
Solar thermal	27%	36%	36%
Geothermal	27%	27%	45%
Biomass and biogas	55%	36%	9%

Offshore windpower dialogue: Location selection

Developers report that location selection is a difficult challenge and something that they would change for future projects. What are the main problems that companies are encountering and what steps can they take to tackle them?

Finding the right location for offshore windpower is subject to many criteria. The investment required to find the right location and to undertake all the necessary research (environmental analysis, wind measurement, foundation surveys etc.) is substantial and is a lost cost if no project funding is found.

Substantial economies of scale can be achieved if some of the 'pre-work' is done collectively or by governments. For example, pre-assigning suitable plots, and doing the environmental analysis and other analysis that is common for all players, will save costs, reduce risks and increase the speed with which offshore windparks can be developed.

Regulatory certainty

A number of governments are weighing up the best way to balance the triple objectives of affordability, security of supply and cleaner energy in a context of tighter public finances. With reviews in countries such as the UK and Germany, there is likely to be a further pause for breath among investors as they wait for clarity on the exact subsidy environment.

Governments will be keen to avoid an investment hiatus as they review subsidy frameworks but, nonetheless, this may be inevitable. Given the central part that a regulated return plays, regulatory certainty is very important for investors in such projects. The need for greater certainty and agreement between the industry and governments is illustrated by the results reported in figure 18.

Ninety per cent of the European utility company survey respondents said discussions between the industry and government about financing and subsidy mechanisms still needed improvement. No government respondents were of the same point of view. Instead, they all rated liaison on financing and subsidy mechanisms as good or satisfactory. There was also a gap in perceptions on the need for improvements to the licensing and permitting process. In contrast, utilities are less worried than governments about the need for better liaison on tariff regulatory frameworks, perhaps mindful that the immediate challenge lies in scaling up the offshore side of the development pipeline.

Part of the challenge for governments is to devise an optimal framework to secure a match between the risk-averse requirements of pension funds and other large institutional investors that have access to the large pools of capital required to fund capital expenditure on offshore windpower expansion. We asked respondents what government measures would most help to stimulate the availability of funding for offshore windpower (figure 19). The responses indicate a clear preference for direct measures – such as increased returns, government involvement in underwriting project risk, funding grid investment and taking direct equity stakes – over indirect measures such as the creation of green tax-free investment wrappers for private investors.

Governments hold the key

Regulatory support and certainty are central to investment in and expansion of offshore windpower. Reviews by some governments have added an element of uncertainty but, in general, the direction of government support is clear. The nuclear emergency in Japan has added a new factor into the equation, the full impact of which is yet to be seen.

The importance of regulatory certainty is highlighted by the financial institutions we spoke with in the survey. Over half (55%) said that they regarded uncertainty in cash flow due to changing government subsidies as a very high risk, with the remainder viewing it as a medium risk. None were comfortable enough to regard government support as a low risk.

Figure 18: Interaction between the offshore windpower sector and government – what needs improving? (Europe)

Needs 'some' or 'a lot' of improvement	Utility company respondents	Government respondents
Financing and subsidy mechanisms	90%	0%
Licensing/permit processes	70%	50%
Grid and other infrastructure developments	40%	50%
Tariff regulatory frameworks	20%	33%

Figure 19: What innovations and developments would improve the availability of funding for offshore windpower projects? (European developers, contractors/OEMs and governments)

	'Strong' or 'very strong' impact
Increased returns to developers through improved support mechanisms such as tax rebates (capital subsidies), duty waivers, soft loan programmes	65%
Government underwriting project risk (through consumer levies, providing loan guarantees, regulated asset structures, financing facilities)	59%
Government bearing cost of laying grid lines	57%
Government taking equity stakes	52%
Development of insurance products to underwrite construction risks	42%
Access to new sources of institutional capital, e.g., pension and insurance funds	42%
Tax-sheltered green investment schemes for private investors	28%

Offshore windpower dialogue: Improved grid access

Improved grid access is seen as critical to offshore windpower expansion. But what is the best way of improving access?

Grid access is proving a bottleneck in all countries trying to realise offshore wind capacity. Connecting windparks is expensive. With ambitious plans, a key question is whether each park should be connected individually or whether planning ahead for a series of parks makes more sense. There are also questions around who should be responsible for the connection – the developer, the national transmission system operator (TSO) or other players?

A modular approach where each park is connected on a stand-alone basis makes sense only if other windpark plans are not yet definite. But if they are, planning the grid connection collectively could allow valuable economies of scale and scope to be achieved that will benefit all offshore windparks and, ultimately, the taxpayer.

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