**You might remember I bought this wind turbine a few weeks ago for one of my previous videos. It’s been up on the bookcase since then, but I thought it might come in handy again today.**

**You see, while onshore wind power is something we’ve all become quite used to seeing in most parts of the world, offshore wind actually represents the biggest opportunity for generating massive quantities of power for our electricity grids. That’s because winds are stronger and steadier at sea than they are on land, so offshore wind delivers a higher power per unit area than onshore wind. Winds out in the open sea often blow during the afternoon too, which means the offshore turbines can provide very useful power at a peak time of the day.**

**We’ve already got loads of offshore winds farms here in the UK and around the coast of some other European countries, but they’re all located in relatively shallow waters, only about twenty-five to thirty metres deep, where everything can be nicely bolted down to the seabed.**

**Now though, the race is on to develop wind turbines that can be towed out into the deep ocean where the winds are even stronger and more consistent. The only snag is that those open ocean waters are far too deep for a tower to be extended down and bolted to the bottom. So apparently these turbines will just float…**

**So, how’re they gonna do that then?**

**Hello and welcome to Just Have a Think**

**The first ever offshore wind farm was opened at Vindeby in Denmark in nineteen-ninety-one. It had a power generating capacity of 5 megawatts, providing for the annual electricity consumption of just over two thousand Danish households.**

**In 2013 a comprehensive review of offshore wind concluded that the benefits to cost ratio was not as good as the industry had suggested and that the “offshore wind market doesn’t look as if it is going to be big”.The review pointed to what it saw as critical disadvantages of offshore installations, including difficulty of access, and harsher conditions like higher humidity, and saltwater corrosion and oxidation which tend to increase maintenance and repair costs and in general make every aspect of installation and operation more difficult and dangerous, and therefore more time-consuming and expensive than sites on land.**

**Despite that pessimism, the offshore wind market has grown strongly. There are now a hundred and sixty-two offshore wind farms around the world with a combined generating capacity of nearly thirty-three gigawatts. That’s more than six thousand times the size of that very first Danish installation.**

**Just last year, another fifteen new offshore wind farms went into operation, with a combined capacity of five point two gigawatts. The majority of those installations are located in Europe and China, but the United States is now starting to get into the market too. President Biden has pledged to deploy thirty gigawatts of offshore wind power within the next decade and the first major project, called Vineyard Wind 1, an eight-hundred megawatt farm off the coast of Massachusetts was announced in May 2021.**

**All these installations stay close to the shoreline where waters are shallow and the distances to large urban conurbations are relatively small. The technology is now fairly mature and there’s forty years of industry knowledge and experience in the field, bringing efficiencies and economies of scale that just weren’t foreseen in that 2013 review paper.**

**So why rock the boat, quite literally, and push out into deep waters where the whole operation takes on far greater risk and expense?**

**Well, here in Europe, wind farm developers are rapidly consuming the low hanging fruit of easily accessible near shore shallow water locations that can be exploited without too much objection from local fishing fleets, conservation groups and coastal residents who complain about having their view spoilt, so going further out to sea is becoming an increasingly urgent consideration. Installing turbines in the open ocean also presents fewer risks for other species that we share our planet with too. Krag Petersen, a wildlife ecologist at Aarhus University in Denmark, says birds like eagles, ducks, griffins, storks, and gannets can collide with the mammoth blades of offshore rigs. But the density of turbines in deep-sea wind arrays is far lower and bird flights are more thinly distributed, so the potential impact on their populations is greatly reduced.**

**Up off the windswept northern coast of Scotland, five towering turbines, each standing a hundred and seventy-four metres tall, make up a renewable energy project called Hywind Scotland, a floating deep-water demonstration wind farm that’s been generating enough electricity for more than 20,000 homes since twenty-seventeen. The giant masts and turbines float in waters more than 90 metres deep, sitting in buoyant concrete-and-steel keels that enable them to stand upright on the water, a bit like a buoy or booey.**

**The cylindrical bases of the turbines weigh**[**10,000-ton**](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=2ahUKEwi30pSpvbXpAhVILewKHbaIDyQQFjACegQIBhAB&url=https%3A%2F%2Fwww.equinor.com%2Fcontent%2Fdam%2Fstatoil%2Fdocuments%2Fnewsroom-additional-documents%2Fnews-attachments%2Fbrochure-hywind-a4.pdf&usg=AOvVaw1Re5o63f142RTMg79pZga2)**s and are held in place with three taut mooring cables attached to anchors, which lie on the sea floor. Each cable has a sixty-ton weight hanging from it’s mid-point to provide additional tension. Control software on board constantly monitors the operation of the wind turbine and alters the pitch of the blades to effectively dampen the motion of the tower and maximise production. So far, the Hywind demo has functioned well in all of the wind and wave conditions the North Sea has been able to throw at it over the past four years, including Hurricane Ophelia in twenty seventeen, and other harsh winter storms bringing hundred mile an hour winds and eight metre high waves.**

**Just a few miles away, off the coast of Aberdeen, the world’s largest floating wind farm received it’s fifth and final turbine in July 2021 and will be fully operational at the start of 2022. The six turbines at the Kincardine installation are the largest machines ever to have been installed onto floating platforms, and they’ll have a generating capacity of fifty megawatts, enough power to run almost sixty thousand Scottish homes.**

**The area beyond the reach of conventional offshore turbines makes up eighty percent of the world’s maritime waters, and the mind-boggling amount of energy available out in the wilds of the open ocean is proving to be just a bit too tempting for turbine makers to ignore. Over in the United States, according to the National Renewable Energy Laboratory, or NREL, the total potential production capacity of offshore wind farms there is nearly double the entire US annual power consumption of four thousand terawatt-hours per year. Forty two percent of that will most likely come from fixed-base offshore turbines in shallow waters off the Eastern seaboard, like those being developed at Vineyard Wind 1. But it’s a very different story on the other side of the country, where the continental shelf drops off very rapidly and you’re into deep water within only a few miles of the shore. The remaining fifty eight percent of US offshore potential power is, according the NREL, therefore locked up in these deep-water ocean areas. And that’s something that American behemoth, General Electric, or GE are fully engaged in trying to liberate.**

**This guy is Rogier Blom. He’s the senior principal engineer for controls and optimization at GE Global Research in Niskayuna, New York. Rogier and his team have designed a 12-megawatt floating version of the Haliade-X, the most powerful offshore wind turbine in the world.**

**These colossal feats of engineering will have two hundred and sixty-metre tall turbines with a rotor diameter of two hundred and twenty metres. Each turbine will be capable of generating 67 gigawatt-hours of electricity a year – that’s enough power to run sixteen thousand American households, just from a single turbine!**

**The system being developed by GE involves bolting the towers to floating platforms, which the development team refer to as floaters, which is unfortunate.**

**But those floaters are essential to carry the turbines’ tremendous weight and respond to the constant motion of the seas and wind. As Blom explains in this GE article from May 2021 “Building a floating wind turbine is like putting a bus on a tall pole and keeping it upright, floating and steady no matter what conditions it faces.”**

**Blom’s plan is for the floating platforms to be tethered to the ocean floor by what he calls ‘actuated tension legs’. “Active tendons” will allow the turbines to ride big waves and reduce the magnitude of the overall mechanical load.**

**GE’s concept is based on what’s called control co-design, in which the entire system — the turbine and platform, as well as the control algorithms — are all designed in tandem. That avoids the need to put additional mass into the system to withstand high winds and waves – something that adds huge cost to the construction of floating oil rigs for example. That cost reduction results in a lower levelized cost of energy or LCOE, which is the standard metric that the energy industry uses to compare different technologies.**

**Some renewable energy experts do still remain sceptical though that the high costs of floating offshore wind turbines will come down far enough to rival other clean-energy technologies. Currently the electricity they generate is often**[**almost twice**](https://www.sciencedirect.com/science/article/pii/S0960148118303690)**as expensive as near-shore wind turbines and three times that of land-based wind turbines. It is still maritime engineering after all, which makes it comparatively expensive to build, deploy, and maintain, with shorter operational lifespans as a result of the corrosive nature of the marine environment that they sit in.**

**But advocates of floating wind point out that costs of onshore and near-shore wind energy have continuously dropped as efficiency and economy of scale have improved over time, and those trends are likely to be the same for floating wind turbines too. They argue that while some of the mechanical details are still being tweaked, the basic technology of floating wind is sound. After all, they say, the oil and gas industry has been using similar marine know-how for decades on their floating platforms in some of the harshest marine environments on the planet.**

**We’re still some years away from a world with hundreds of deep sea floating wind turbines providing huge quantities of renewable energy to major populations all over the planet, and the roll out of these facilities at the sort of scale required, will certainly call for big backing from governments and corporate investors who will, of course, need to be convinced of the long-term capital returns.**

**As Frank Adam, and expert on wind energy technology at Rostock University points out in this BBC interview,**

**“It’s easy to produce one or half-dozen floating turbines, but 10 or 20 or 100, that’s another story. This requires supply chains, shipyards, and ports that can handle such enormous structures, and factories for serial fabrication”**

**Nevertheless, despite these challenges, the potential of this renewable energy generation remains an attractive proposition, and the amount of energy that could be produced would be globally transformational. The International Energy Agency projects that** [**offshore wind power**](https://www.iea.org/reports/world-energy-outlook-2019)**alone could eventually meet the entire electricity needs of Europe, the US, and Japan many times over. And if China does dive into offshore wind like they have done with all other renewable energy technologies, then it may just provide yet another route for them to slow down and even reverse their currently unsustainable schedule of opening the equivalent of a new coal mine every week.**

**If you’ve got news or views on this one, or if you have direct experience in the industry that you’d like to share, then jump down to the comments section below, and leave your thoughts there.**

**That’s it for this week though.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week.**