FLUIDS-BUOYANCY

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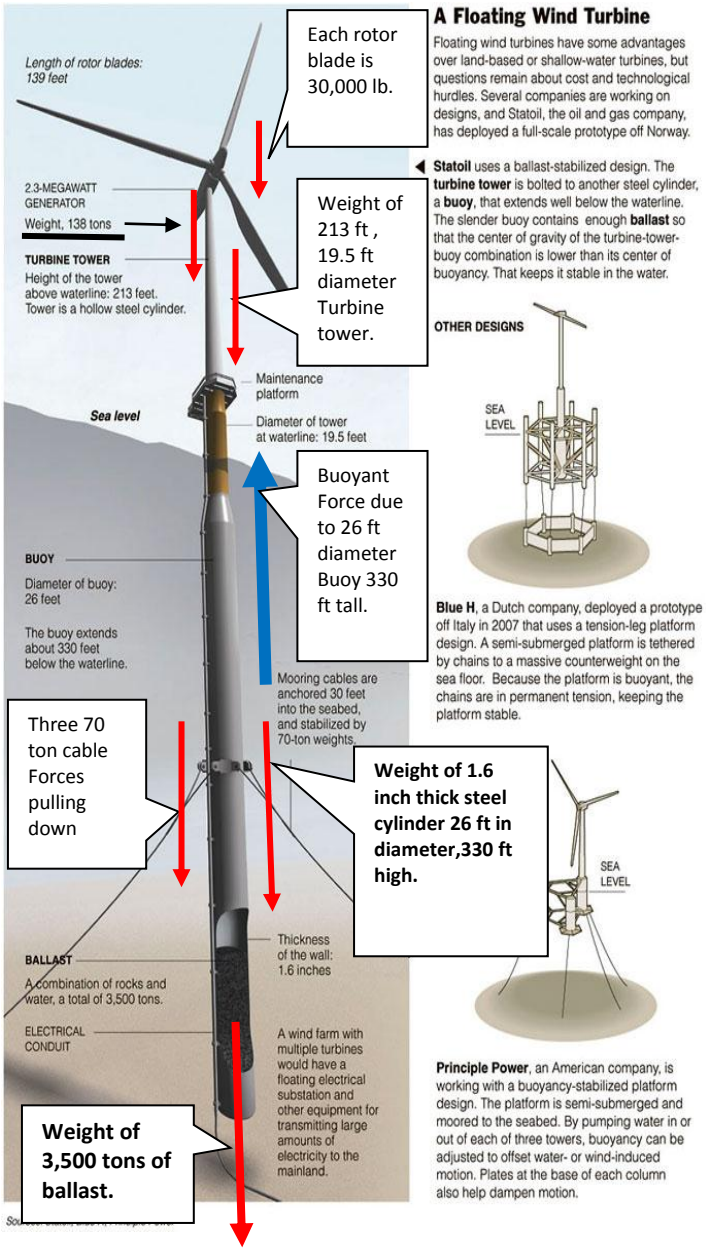
Seeking Wind Energy, Some Consider the Sea

LAST June in a fjord in southwestern Norway, a 213-foot-tall wind turbine did something large wind turbines normally don't do: it headed out to sea. Towed by tugboats, the newly built turbine, with three 139-foot rotor blades and a 2.3-megawatt generator atop the tower, which itself was bolted to a ballasted steel cylinder extending more than 300 feet below the waterline, made its way to a spot six miles off the coast. Once in position it was moored with cables to the seafloor, about 700 feet below.



A Floating Wind Turbine

Floating wind turbines have some advantages over land-based or shallow-water turbines, but questions remain about cost and technological hurdles. Several companies are working on designs, and Statoil, the oil and gas company, has deployed a full-scale prototype off Norway.

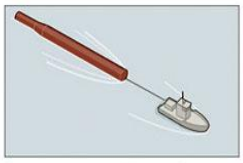
Statoil uses a ballast-stabilized design. The **turbine tower** is bolted to another steel cylinder, a **buoy**, that extends well below the waterline. The slender buoy contains enough **ballast** so that the center of gravity of the turbine-tower-buoy combination is lower than its center of buoyancy. That keeps it stable in the water.

OTHER DESIGNS

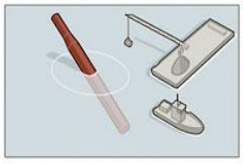
Blue H, a Dutch company, deployed a prototype off Italy in 2007 that uses a tension-leg platform design. A semi-submerged platform is tethered by chains to a massive counterweight on the sea floor. Because the platform is buoyant, the chains are in permanent tension, keeping the platform stable.

Principle Power, an American company, is working with a buoyancy-stabilized platform design. The platform is semi-submerged and moored to the seabed. By pumping water in or out of each of three towers, buoyancy can be adjusted to offset water- or wind-induced motion. Plates at the base of each column also help dampen motion.

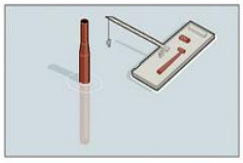
ASSEMBLING THE STATOIL TURBINE



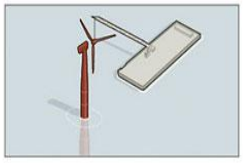
The empty steel buoy is towed from the manufacturing plant to a deepwater site.



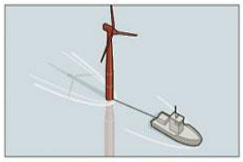
Ballast is slowly added to the buoy so that the bottom end starts to sink and the spar becomes upright.



The turbine tower is brought to the site, raised by a barge-mounted crane and bolted to the buoy.



The generator and rotor assembly are installed. The ballast is adjusted so that the turbine is at the proper height in the water.



The turbine is towed to its final offshore location, where it is attached to mooring cables anchored in the seabed.

MIKA GRÖNDAHL/THE NEW YORK TIMES

INTRODUCTION: Objects are buoyed up by a force equivalent to the weight of the fluid displaced. Density of water is 62.4 lb/ft^3 , density of steel = 460 lb/ft^3 ., volume of cylinder wall of known thickness = pi([$r_{outside}$]^2 – [r_{inside}]^2) x length. **QUESTIONS:** (a) Find buoyant force due to the displaced water by the 330 ft tall 26 ft diameter buoy beneath the water? (b) Find weight(in lb) down due to Ballast?,(c) Find weight of 330 ft tall steel buoy cylinder ?,(d) Find weight(in lb) of 213 ft tall,19.5 ft diameter steel turbine tower?,(e)Express the weight of generator in lbs?,(f) Express the total weight of the three rotor blades in pounds?,(g) Express the total force down due to the three 70 ton cables in pounds?(h) Add up all the downward forces from (b) to (g)? This should be six numbers added.(i) How does the buoyancy force up compare to the total of all downward forces found in (h)? (j) Does the answer in (i) seem reasonable and within plausible range?

ANSWERS: (a) ~ 10.93 x 10^6 lb. (b) ~ 7 x 10^6 lb ,(c) ~ 1.66 x 10^6 lb, (d) ~ 0.8 x 10^6 lb., (e) ~ 0.276 x 10^6 lb., (f) ~ 0.090 x 10^6 lb., (g) ~ 0.42 x 10^6 lb, (h) ~ 10.25 x 10^6 lb. (i) _____, (j) _____.