ReaLCoE

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Developing the Next Generation 12+ MW Offshore Wind Turbine for Clean and Competitive Electricity

Industry shift from «Soft-Stiff» to «Stiff-Stiff» tower

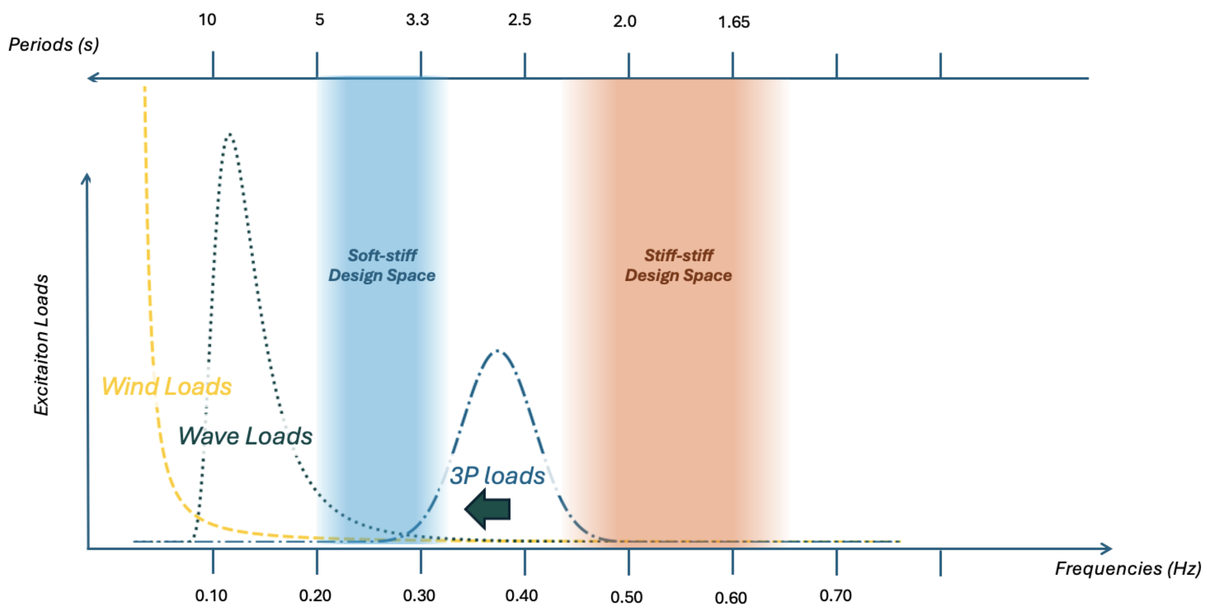

Figure 1: Floating wind turbine loads and design space region

Design Space for Floating Wind Turbines

When designing a floating wind turbine, engineers pay close attention to the location of the coupled system eigenfrequencies. Maintaining a safety margin between the load frequencies is crucial to avoid a resonant system response, as this could result in severe fatigue damage to the tower-platform interface. In particular, the value of the "coupled tower eigenfrequency" (i.e. the rate at which the tower on top of the floating foundation undergoes one complete cycle of oscillation in the absence of disturbance) is finely tuned. As presented in Figure 1, two main design spaces can be explored: "soft-stiff" systems have their coupled tower eigenfrequency in between "1P" (i.e. the rotor spinning frequency) and "3P" (i.e. the blade passing frequency), whilst "stiff-stiff" systems have the coupled tower eigenfrequency above 3P. As WTG sizes increase, the soft-stiff design space effectively decreases; this occurs because larger turbines spin more slowly, causing the 3P load frequencies to decrease and narrow the available operational window.

Wind Turbine Manufacturer's Challenge

The Wind Turbine Manufacturer's 'soft-stiff' approach , the one used for ReaLCoE project, is susceptible to a 'Design Spiral' challenge, whereby high fatigue loads prompt the addition of thicker tower bottom shell plates. The increased thickness makes the tower stiffer, bringing the first eigenfrequency closer to the 3P rotational frequency. This ultimately results in even higher fatigue loads, at which point the wind turbine manufacturer must decide to switch to a 'stiff-stiff' condition.

In the 'stiff-stiff' condition the coupled system eigenfrequency needs to be significantly increased to avoid any resonance with 3P rotational frequency, to achieve this configuration the tower base diameter and thickness need to be modified, also the floater mass and inertia can play a big role to increase the coupled eigenfrequency.

Given these dynamics, Original Equipment Manufacturers (OEMs) tend to move towards a 'stiff-stiff' tower design for WTG capacities higher than 15 MW, to ensure structural integrity and avoid the complexities of the design spiral in ultra-large-scale units.

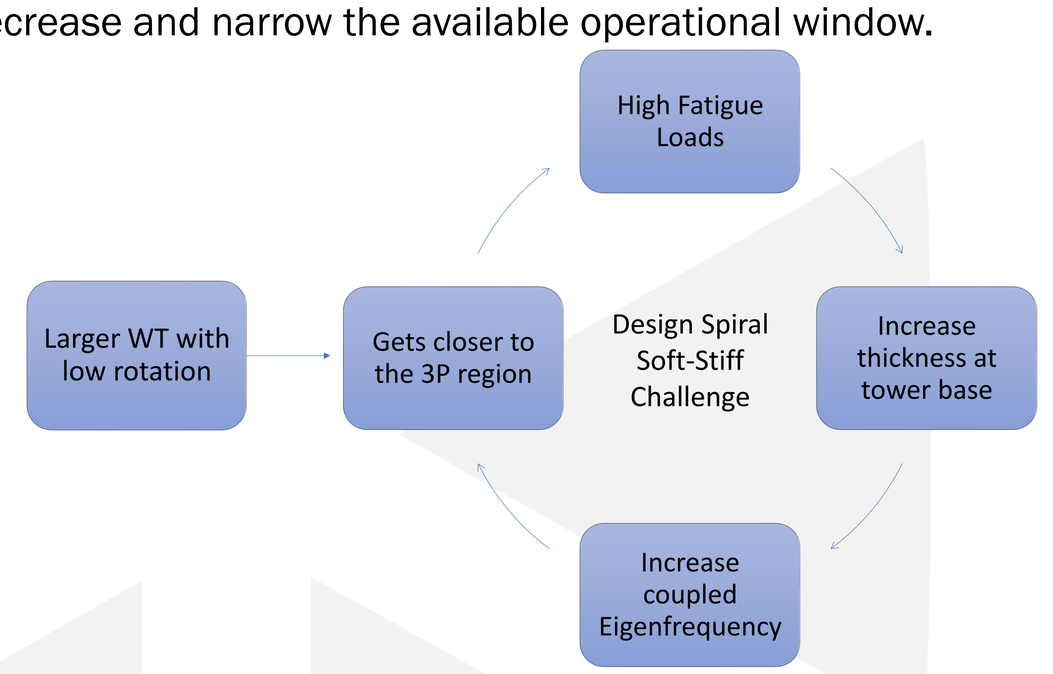

Figure 2: Design Spiral Soft-stiff Challenge

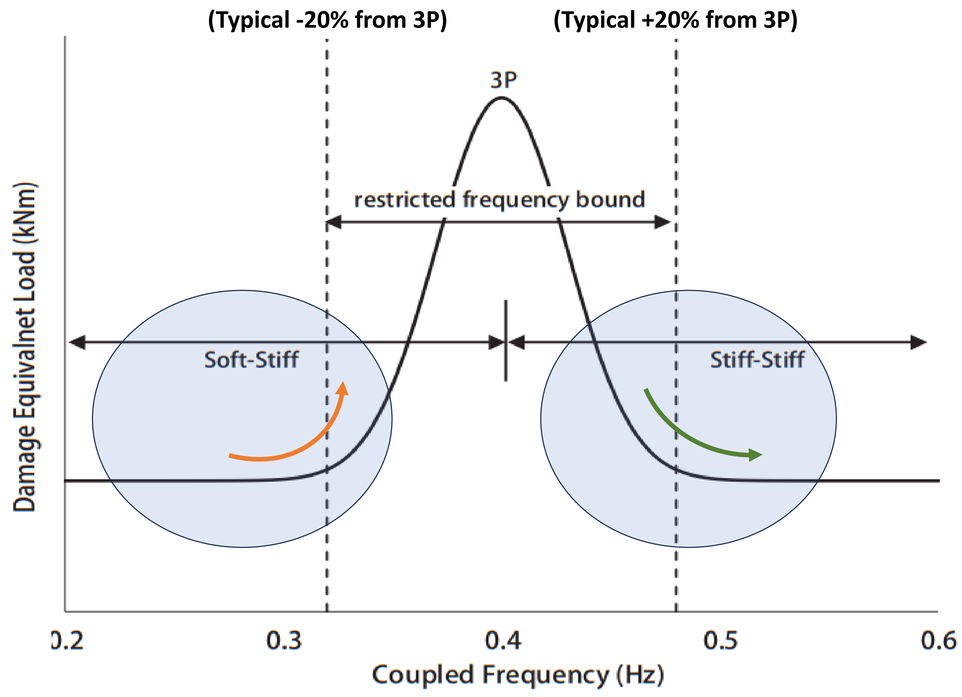

Figure 3: Damage equivalent load by coupled frequency

ReaLCoE's vision is to unleash the full potential of offshore wind energy
€35/MWh LCoE Goal, +12MW WEC Capacity, ~32 mio € Total Budget, 42 month project duration

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