This paper investigates the influence of system-level innovations on the fatigue life of jacket substructures for offshore wind turbines. The innovations consist of active control strategies as individual pitch control and individual flap control. Further, the effect of a magnetic pseudo direct-drive generator (PDD) mounted upfront the rotor is investigated. Fully-coupled aeroelastic simulations are performed for 10 MW and 20 MW wind turbines, with the selected innovations, supported by jacket structures under specific met-ocean conditions at 50 m of water depth. Fatigue limit states at the jacket' welded joints are evaluated based on S-N curves and Miner's rule according to DNV-RP-C203 guideline. Results show the potential of advanced control systems to reduce stresses at jacket members. Few design challenges characterize PDD models, as increased tower base torsional loads and excitation of global bending modes may be critical for jacket's members. Altogether, this study indicates the benefit of an integrated-iterative design approach for jacket substructures, where system-level parameters are iterated along with the jacket design parameters using fully-coupled models.