PROJECT 08 | DOE/NREL: Wind Turbine Drivetrain Emergency Stop

REAL-WORLD CASE • ENGR 3122 • FOUR-WEEK TEAM PROJECT

Engineering situation

DOE documents dynamometer testing of wind turbine drivetrains and braking-related gearbox loads. Analyze an equivalent rotating drivetrain under emergency braking.

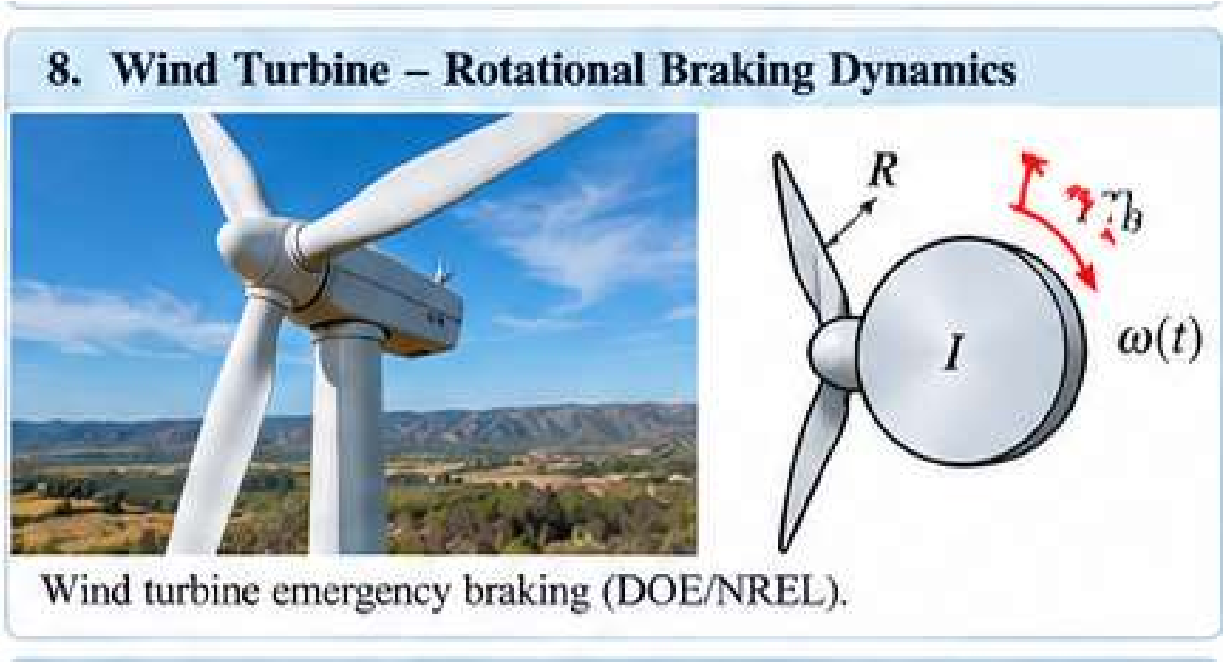


Figure 8. Real-world visual context (left) and simplified dynamics schematic (right). AI-generated illustration; not a source photograph or dimensioned drawing.

Source and data provenance

Original documented case: https://www.energy.gov/cmei/systems/articles/blade-and-drivetrain-testing-advance-wind-turbine-efficiency-and-reliability

Published-case context (do not treat as a complete model): DOE reports 2.5 MW and 5 MW dynamometer facilities; the equivalent inertia and braking torques below are instructional.

Instructional numerical model — prescribed for this assignment

The following numbers are classroom modeling assumptions unless specifically identified above as published values. Use them as given; do not infer they were measured in the original event.

Rotor-side equivalent inertia	**4.5 × 10^6 kg·m^2 (assumed)**
Initial rotor speed	15 rpm (assumed)
Aerodynamic driving torque during stop	0 N·m (assumed feathered blades)
Target stop time	25 s
Constant braking torque	Unknown; solve for it
Alternative two-stage braking	First 10 s at 60% of baseline torque; remaining at constant higher torque
Maximum permissible torque	360 kN·m (instructional constraint)

Required calculations and engineering questions

(a) Convert 15 rpm to rad/s and calculate initial rotor angular momentum and kinetic energy.

(b) Derive the constant braking torque necessary to stop the rotor in 25 s.

(c) Determine braking power at the beginning and the average power dissipated during the stop.

(d) Calculate total angular displacement and number of revolutions before stopping.

(e) For the two-stage braking schedule, determine the second-stage torque needed to stop in 25 s.

(f) Determine whether either schedule meets the 360 kN·m limit and compare peak torque.

(g) Study stopping times from 15 to 60 s and determine the shortest constant-torque stopping time consistent with the limit.

Modeling and submission checks

MATLAB: rotor ω(t), torque(t), and dissipated energy. Explain why gearbox transient dynamics are omitted.