The last few years have seen a rapid increase in wind energy installations across the world. Wind turbines are now the largest rotating machines ever built; in order to produce substantial amounts of power, these are often deployed in large arrays, which can comprise hundreds of units. The resulting flows are complex, involve a wide range of length and time scales, and pose significant modeling challenges. By comparison, tidal energy is, at present, a less utilized resource. Among other issues, very large uncertainties still affect the estimates of available fluid power at tidal sites. Overall, large-scale fluid energy extraction constitutes an emerging topic in engineering, which is likely to play a key role in human endeavors over the next decades.

This course covers the underlying fluid mechanics of these systems, with an emphasis on quantitatively estimating available resources and power extracted.

Topics include: Rotor modeling: streamtube theory, blade element models, theoretical efficiency, rotor optimization, horizontal vs vertical-axis turbines; Wake models: similarity solutions, Ainslie model, Park model, entrainment models, wake interactions, layout optimization; The planetary boundary layer: log-law and power-law descriptions, effects of rotation, stratification, ambient turbulence; Tidal channels: open-channel flows, shallow-water models, effects of topography. Boundary-layer and canopy models: the double-averaged fluid equations, log-law approximations, layer-averaged models, developing and fully-developed flows. Numerical simulation: overview of RANS & LES, their capabilities and limitations.

Prerequisite courses: ME152A and ME152B, or permission of instructor. The undergraduate and graduate versions have different assignments and exams.