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Hydroeconomic Analysis of the Balance between Renewable Wind Energy, Hydropower, and Ecosystems Services in the Roanoke River Basin

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Hydropower can provide inexpensive, flexible fill-in power to compensate for intermittent renewable generation. Policies for hydropower dams maintain multiple services beyond electric generation, including environmental protection, flood control and recreation. We model the decision of a hydroelectric generator to shift some of its power production capacity away from the day-ahead energy market into a "wind-following" service that smoothes the intermittent production of wind turbines. Offering such a service imposes both private and social opportunity costs. Since fluctuations in wind energy output are not perfectly correlated with day-ahead energy prices, a wind-following service will necessarily affect generator revenues. Seasonal wind patterns produce conflicts with the goal of managing rivers for "ecosystem services" – the maintenance or enhancement of downstream ecosystems. We illustrate our decision model using the Kerr Dam in PJM's territory in North Carolina. We simulate the operation of Kerr Dam over a three-year period that features hydrologic variability from normal water years to extreme drought conditions. We use an optimization framework to estimate reservation prices for Kerr Dam offering wind-following services in the PJM market. Wind-following may be profitable for Kerr Dam at low capacity levels during some time periods if ecosystems services are neglected and if side payments, or reserves-type payments, are provided. Wind-following with ecosystem services yields revenue losses that typically cannot be recovered with reserves market payments. Water release patterns are inconsistent with ecosystem-services goals when Kerr Dam dedicates significant capacity to wind-following, particularly in drought years.