We investigate wake effects at the Anholt offshore wind farm in Denmark, which is a farm experiencing strong horizontal wind-speed gradients because of its size and proximity to land. Mesoscale model simulations are used to study the horizontal wind-speed gradients over the wind farm. From analysis of the mesoscale simulations and supervisory control and data acquisition (SCADA), we show that for westerly flow in particular, there is a clear horizontal wind-speed gradient over the wind farm. We also use the mesoscale simulations to derive the undisturbed inflow conditions that are coupled with three commonly used wake models: two engineering approaches (the Park and G. C. Larsen models) and a linearized Reynolds-averaged Navier–Stokes approach (Fuga). The effect of the horizontal wind-speed gradient on annual energy production estimates is not found to be critical compared to estimates from both the average undisturbed wind climate of all turbines’ positions and the undisturbed wind climate of a position in the middle of the wind farm. However, annual energy production estimates can largely differ when using wind climates at positions that are strongly influenced by the horizontal wind-speed gradient. When looking at westerly flow wake cases, where the impact of the horizontal wind-speed gradient on the power of the undisturbed turbines is largest, the wake models agree with the SCADA fairly well; when looking at a southerly flow case, where the wake losses are highest, the wake models tend to underestimate the wake loss. With the mesoscale-wake model setup, we are also able to estimate the capacity factor of the wind farm rather well when compared to that derived from the SCADA. Finally, we estimate the uncertainty of the wake models by bootstrapping the SCADA. The models tend to underestimate the wake losses (the median relative model error is 8.75 %) and the engineering wake models are as uncertain as Fuga. These results are specific for this wind farm, the available dataset, and the derived inflow conditions.