EXPERIMENTAL INVESTIGATION OF AXIAL-FLOW TURBINE ARRAYS IN SANDY CHANNELS.

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Opportunities to deploy current energy converters (CEC), such as axial-flow turbines, in fluvial environments remains largely unexplored. While rivers are a potential and continuous source of exploitable kinetic energy, they also represent a delicate morphodynamic system which may be affected by the deployment of turbine arrays necessary for economically viable power production. To investigate these effects, a staggered array of twelve axial-flow marine hydrokinetic (MHK) turbine models was tested at the St. Anthony Falls Laboratory under live-bed sediment transport conditions. The interaction between the MHK power plant and the complex migrating bedforms was monitored using a state-of-the-art high-resolution submersible laser scanning device able to provide spatio-temporally resolved channel bathymetry $z(x,y,t)$. Results reveal two scales of geomorphic effects: a localized scour downstream of each individual turbine and a cumulative array-scale distortion of the mean topography. The former is inferred to be the result of the flow acceleration between the lower rotor tip and the erodible bed as a consequence of the blockage effect of the operating rotor. Predicting this local scour is of extreme importance for the structural integrity of CEC foundation since the erosion at the base of the turbine is observed to be significantly larger than that created by bridge piers [1], and thus requiring the development of a specific predictive model [2]. The array-scale geomorphic effects are identified as an alternate scour-deposition pattern in the mean bathymetry, spatially decaying downstream from the turbine array. Additionally, measurements of flow velocity within the array and estimates of the turbine angular velocity provide a qualitative description of the power plant energy output consistent with observations in wind farm models. The overall outcomes show that array-scale deployment of CEC technologies in sandy rivers can provide substantial energy output with limited geomorphic impact far downstream.

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REFERENCES

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