Optimizing Building Geometry to Enhance Wind Turbine Energy Capture in Urban Environments

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The motivation of this project was to modify the geometry of high-rise buildings in urban environments, directing and accelerating extreme winds effectively into turbines to generate energy. To achieve this, I went through an elaborate process to find the most effective of six buildings, each using different implementations of different natural phenomena to assist in accelerating wind. The main effects that I focused on for each building design was the Venturi effect, coanda effect, and orthographic speed-up effect. The six buildings include a funnel-type building utilizing the Venturi effect, two different designs of slope-type buildings for the orographic speed-up effect, a raindrop shape design utilizing the coanda effect, a tunnel building utilizing all three effects, and a basic rectangular structure as the control. After designing each building, I used CFD software to test the effectiveness of each building. After refining and rerunning simulations on the buildings, the control and two best buildings were 3D printed and tested in a physical wind tunnel. The numerical data showed that the basic control building accelerated the wind the fastest at 101% the original incoming wind speed. Though the wind accelerated faster with the control building, the "droplet" building, utilizing the coanda effect, had significantly less turbulence. This allowed a more consistent airflow. The control building having a higher amount of turbulent kinetic energy makes it difficult to collect the wind speed generated. The droplet building is the best design to direct and accelerate the extreme wind effectively into turbines to generate wind energy.

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