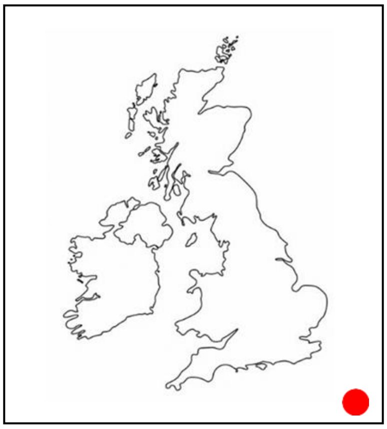
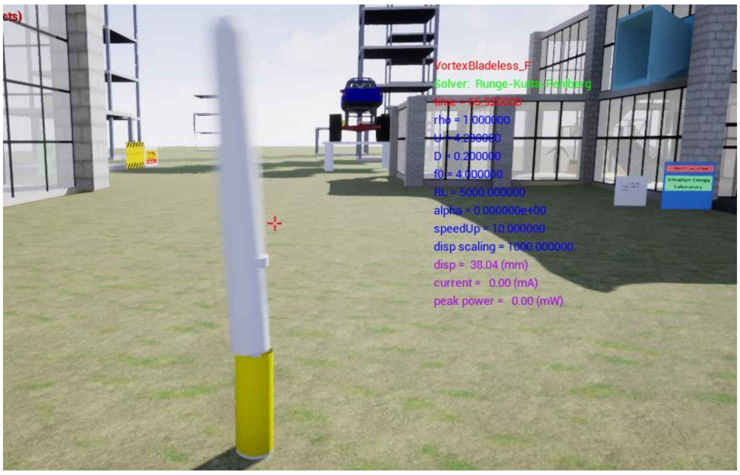
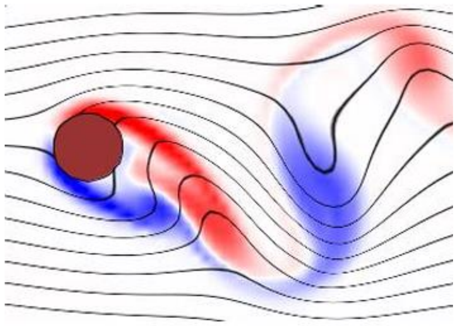


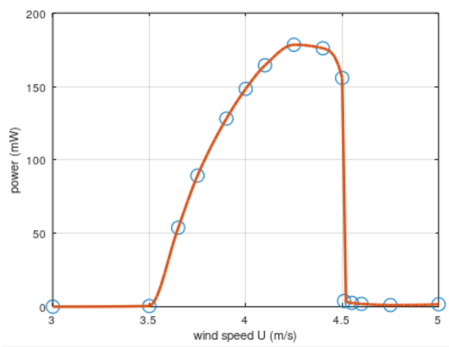
Vortex Bladeless

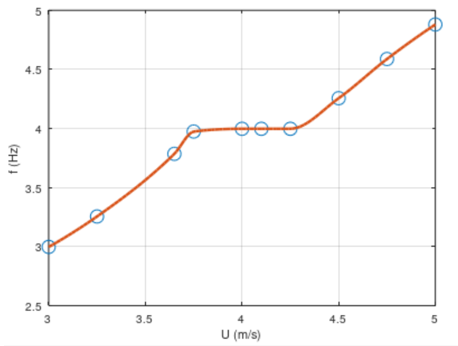


Background. When a fluid passes by the cylinder, it sheds vortices periodically which makes the cylinder oscillate. The frequency of the vortices is $f_v = 0.2\frac{U}{D}$ where D is the cylinder diameter and U is the fluid speed. The cylinder can be modelled as a mass m on a spring with stiffness k and this has a natural frequency $f_o = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$. Theory predicts a narrow range of fluid speeds where the amplitude of the cylinder is large, and where the vortices 'lock on' to f_o. This is the 'operating' region of the device where it produces most power. The graphs on the right show what to expect.

Power take-off uses magnets and coils, the relative motion between cylinder and base induces a current which flows through the load resistor **RL**. The strength of this coupling is parameter **alpha.** Of course power take-off reduces the amplitude of oscillation so increasing the coupling strength to a large value may not increase the power delivered. So there will be a tradeoff here.







Files and Levels.

Level **Science Park,** actor **MAS22_VortexBladeless_F.**

Octave script **Facchi_F.m** Plots two variables as a function of windspeed. You can decide what to plot.

Parameters (Independent Variables) available:

U wind speed
RL load resistor (PTO)
alpha magnet-coil coupling (PTO)
speedup make time run faster.
disp scaling make motion larger.
D cylinder diameter
rho air density
f0 cylinder natural frequency of oscillation

Dependent Variables to observe:

HUD
disp displacement of cylinder
current generated current
peak power at any time

Octave File (as a function of time)
time, disp, current, power
alpha (rotation of the vortex oscillator)

Ideas to Get Started

Study 1. Turn off the PTO (set **alpha = 0**) and study the vortex oscillator on its own.

Change the windspeed **U** and measure the **disp** of the cylinder and the oscillation frequency (Octave will plot a spectrum showing how much of various frequencies are produced.

Make 2 plots using **Facchi_F.m**, they should look like the examples above.

Study 2. Investigate the effects of **alpha** and then **RL** in producing power.

Choose a windspeed from study 1 which gives a large oscillation amplitude. Keep this constant.

Investigate values of **alpha** recording (at least) the power produced. More **alpha** means more magnet-coil coupling and therefore more power. But **alpha** also damps the oscillations, so less power. There's a tradeoff here, see if you can find the optimal **alpha**.

Now choose a suitable value of **alpha** and keep this (and the wind speed) constant. Now change **RL** and see if you can find an optimum.

Study 3. Investigate the entire device.

Set **alpha** and **RL** to the values you have found and change the windspeed as you did in Study 1, and plot the power and frequency as a function of windspeed. This will help you to understand the device.

Hints for Roundup

How well does a Vortex Bladeless compare with a classic wind turbine? One way to compare is to calculate the *efficiency* of the turbine, what fraction of power available in the wind is actually extracted. Here's the formula,

$$\eta = \frac{P_{device}}{\frac{1}{2}\rho\pi R^2 U^3}$$

A classic wind turbine has an efficiency of at least 0.5 (50%).

You could calculate how many of these turbines would be needed to run a house (I am currently drawing 733W). Or you could calculate how many Vortex Bladeless would be needed to replace a single classic wind turbine.

Can you see any positive or negative social impacts – how do you think people would respond to a proposed bladeless wind farm. Some people suggest that classic turbines kill a large number of birds, but bladeless will not. Do you think either of these positions could be true?

Perhaps research the history of Vortex Bladeless, what various blogs and posts have to say about it. Are there any devices currently in service? Can you find any studies of their performance?

Domestic electrical energy consumption per household per year (2023) is 2700 kWh, which means an average continuous power draw of 2700/(365*24) = 0.31kW.

7 AFFORDABLE AND CLEAN ENERGY