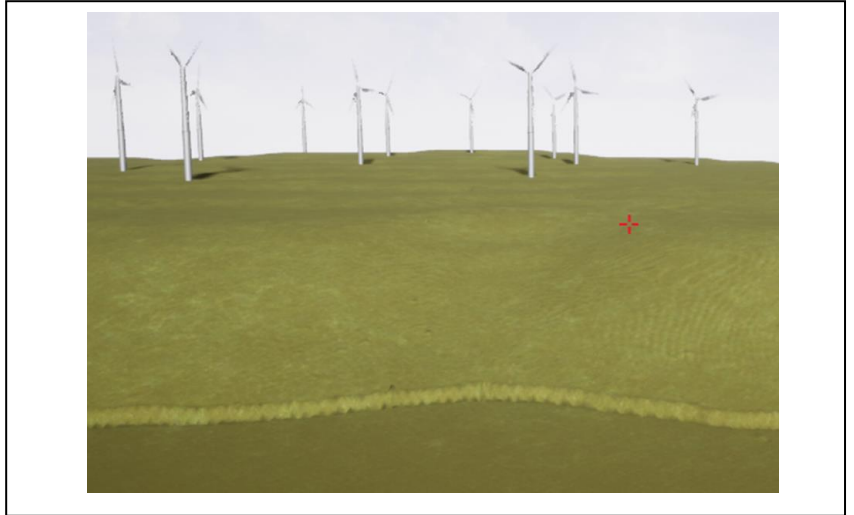Background. On-shore wind farms involve a collection of turbines. Their placement is influenced by local geography, planning regulations and technical aspects. Turbine placement should be optimized to extract the maximum power, under constraints of geography and planning. Here we shall explore the technical aspects; there are two levels, one where you can place the turbines as you choose, the second is a real wind farm at Glenapp, where you can tweak the turbine locations.

Wind passing through a turbine produces a 'wake' behind the turbine; the wind velocity drops suddenly behind the disc (blades) then recovers as air mixes in from outside the disc. You can see this in the diagram below left, red is wind at 8 m/s and blue is lower, just behind the disc, the speed drops to just under 4 m/s.
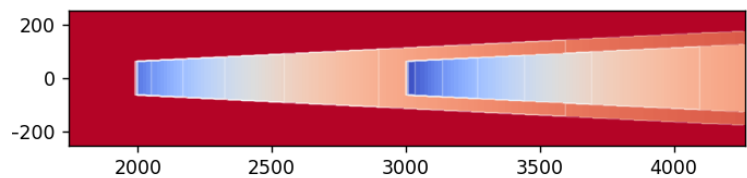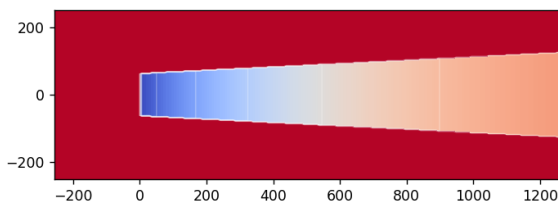
The diagram top right shows a second turbine in the wake of the first, it is clearly in a region of wind speed less than the ambient 8 m/s so it will produce less power than the upwind turbine. How much depends on its placement, how far away it is from the first, and how much overlap there is with the wake of the first. This is the technical aspect of turbine placement which you will study.

Files and Levels.
* Level **Wind Farm** which is a flat landscape where you can design and build your own farm. Level **Glenapp** which is a real windfarm in Scotland with the turbines located for you.
* Input scripts in the folder **Layouts** where you enter the coordinates of your farm
* CFD wake plotter **Floris** to make figures like the ones above.
* Book Chapter.

Parameters (Independent Variables) available

Locations of the files in the layout scripts
Wind speed (P-key)

Dependent Variables to observe:

HUD: Individual turbine speeds and powers, plus total farm power.

Octave dump: total power as a function of time.

How to specify your layout. The layout scripts are located in the folder **Layouts.** Each turbine has its own line, e.g., the line below starts with the key word **Turbine** then comes a name **turb2** then (x,y,z) so this turbine is at x = 0, y = 200, z = 0, then comes three angles to orient the turbines into the wind, leave these alone then a line terminator **E.** Distances in metres, angles in degrees.

Turbine, turb2, 0, 200, 0,   0, 0, 90,   E

You specify the layout to load in the script **MAS22_System.ini** in the **Saved/Config** directory. At the bottom you will see **FarmLayoutFile = "Layout1.txt"** just insert your layout file name here.

Wind is blowing in the positive x direction, look for the axes icon in the level.

Ideas to get started.

Study 1. Investigate the interactions between two (then several) turbines. Decide on some layouts. Start with simple arrangements, and change some variable, such as the spacing between the turbines and see how this affects the power produced by each turbine and hence total power. You may want to use **Floris** to help understand wake overlap.

Study 2. Look at the **Glenapp** layout as it is, record the turbine powers. You will need to set the layout to **"GlenappCorr.txt"** in the .ini file.Now think about the likely wake interactions and decide how to move one or more turbines to increase the total power. Plan your investigation sensibly, changing one turbine at a time. Finally you should end up with a tweaked layout.

Other ideas. The wind-speed is provided as a parameter. You could investigate how the total power depends on wind speed. A typical turbine will vary its power in the regio 5 – 11 m/s, under 5 m/s it does not rotate,

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Hints for Roundup

This is all about turbine interaction so that should be your focus. But you could also reflect on wind power in the broad. For example, how many homes could a farm like Glenapp power? What was the effect of your layout tweak on the number of homes powered?

What are possible social impacts of a windfarm site? Try to find out the nature of consultations made and reports written before a licence is granted.

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.