## Work-linked internship at IFP Energies nouvelles (IFPEN)

# Flow analysis in wind farms using the EMD method

The phenomenon of meandering describes coherent variations in the trajectory of a wind turbine's wake. This generates specific mechanical stresses on turbines located in the wake of other turbines, thus influencing the design and production prediction of wind farms. Wake meandering is closely linked to the large scales of atmospheric turbulence, but its exact behaviour remains poorly understood, particularly for non-canonical cases or cases with several wakes. They are subject to the complex influence of various disturbances such as turbulence, wind turbine operation and rotor movements. Understanding these phenomena is crucial to determining the optimum locations for wind turbines. Large-scale simulation is a powerful tool for predicting these unsteady flows, but extracting the key flow characteristics from the vast data generated represents a major challenge. At present, the scientific community lacks a robust and effective methodology for tracking wakes, even in the most complex cases (floating wind turbines in motion, strong turbulence, superimposed wakes, etc.). Various techniques can be used to separate the turbulence from the mean field in order to identify the predominant structures in the flow. EMD (Empirical Mode Decomposition) is a data-driven method specifically designed to analyse non-linear and non-stationary phenomena. It is already used to analyse atmospheric flows and has been adapted at IFPEN to study flows in confined environments, such as piston engines.

**Main tasks and activities:**

This project aims to exploit the potential of the EMD technique to describe the spatio-temporal evolution of meandering based on 2D and 3D velocity field data available at IFPEN and derived from large-scale simulations (LES).

- Bibliographical review of unsteady flow analysis techniques
- Application of EMD to the velocity field behind a wind turbine and analyses
- Application of EMD in a wind field and analyses
- Integration into Python and evaluation of possible improvements (advanced EMD methods or other) based on the latest bibliographic advances.

**Keywords** : CFD, wind fields, EMD analysis, wake, turbulence

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| **Academic requirements** | Master degree ou or engineering school |
| **Desired experiments** | Internship or project in CFD or data analysis/image processing |
| **Compétences techniques et aptitudes** | Fluid mechanics, CFD, signal and image processing, scientific computing, Linux, Python |

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