

# Environmental Transport Phenomena

## Mini Project Topics

This document summarizes the four available topics for your mini project. Its purpose is to give you a clear overview of each topic, including objectives, main tasks, and some expected results, so you can choose the one that best suits your interests.

The four project topics are: River Flow, Flow over Topography, Street Canyon Flow, and Wind Turbine Flow. Each project follows the same general workflow:

- Build or import the **geometry**.
- Generate a suitable **mesh**.
- Set up and run the **CFD simulation** in Fluent.
- Perform **post-processing** to analyze results.

You will receive the material for your selected project from your TA in week 6.

## 1. River Flow

### Overview

You will study the flow mixing at the junction of the Rhine and Neckar rivers in Mannheim, Germany. The case uses a simplified geometry and hypothetical flow conditions to capture the essential mixing behavior.

### Tasks

- Import river boundaries from a provided coordinate file and construct the geometry.
- Generate the mesh with appropriate boundary conditions (two inlets, one outlet, and riverbanks as walls).
- Set up the flow simulation in Fluent with water as the working fluid and energy transport enabled.

### Results

- Visualize **turbulent kinetic energy (TKE)**.
- Compare **temperature distribution** at two cross-sections (just after the junction and before the outlet).
- Report the **area-weighted average outlet temperature**.
- Provide a short report describing your meshing strategy and simulation outcomes.

## 2. Street Canyon Flow

### Overview

This case models airflow inside a simplified street canyon, which represents a street flanked by buildings on both sides. A pollutant source is included, and the study focuses on how wind and turbulence influence pollutant dispersion and temperature patterns.

### Tasks

- Create the street canyon geometry and define the pollutant source.
- Generate a refined mesh near the buildings, including inflation layers.
- Run the CFD simulation with species transport enabled and realistic boundary conditions for wind inflow, pollutant source, and outlet.

### Results

- Contours of **velocity magnitude** and **turbulent kinetic energy**.
- Line plots of **pollutant (CO) concentration** at specific vertical profiles in front of buildings.
- Average **temperature values** at the same profiles.
- Mesh quality metrics and discussion of your meshing approach.

## 3. Flow over Topography

### Overview

This project investigates how wind flows over a simplified hill shape. The study highlights acceleration over the hill, turbulence generation, and the link to potential wind energy production.

### Tasks

- Build the 2D hill geometry and generate the mesh with proper boundary conditions (inlet, outlet, symmetry, wall).
- Set up the flow in Fluent using a turbulence model and specified inlet conditions.
- Run the steady-state simulation and monitor convergence.

### Results

- Contours of **velocity** and **turbulent kinetic energy (TKE)**.
- Vertical profiles of **potential energy production** at the inflow and over the hill.
- Discussion of where the flow accelerates and where turbulence is highest.
- Mesh visualization and quality evaluation.

## 4. Wind Turbine Flow

### Overview

This case models the flow passing through a simplified wind turbine. The turbine is represented as a porous body that extracts momentum from the flow, allowing you to study wake effects and power production.

### Tasks

- Construct the 2D geometry and generate the mesh, including a turbine zone.
- Apply boundary conditions for wind inflow, outlet, symmetry, and wall roughness.
- Enable momentum source terms in the turbine zone to represent power extraction.
- Run the steady-state simulation in Fluent and monitor convergence.

### Results

- Contours of **velocity** and **turbulent kinetic energy (TKE)**.
- **Power production** of the turbine.
- Streamwise profiles of **velocity** and **potential energy production** at hub height.
- Mesh visualization and quality evaluation.