POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

## THEMATIC Research Field: EXTREME EVENTS AND HIGH WINDS UNDER CLIMATE CHANGE: IMPLICATIONS FOR BOUNDARY LAYER MODELLING AND STRUCTURAL INTERACTION

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **1500.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
| --- | --- |
| **Motivation and objectives of the research in this field** | The increasing frequency and intensity of extreme atmospheric events represent one of the most evident manifestations of climate change. Among these, high and gusty winds pose a growing risk to infrastructure and large-scale structures, highlighting the need for an improved understanding of the physical processes occurring within the Atmospheric Boundary Layer (ABL) and its interactions. The turbulent characteristics of the ABL, influenced by terrain topography, surface roughness, and local meteorological conditions, are fundamental to the accurate numerical modelling of aerodynamic loads.<br><br>Computational simulation of atmospheric flows under extreme wind conditions requires advanced Computational Fluid Dynamics (CFD) approaches capable of reproducing the turbulent structure of the wind and its interaction with tall buildings, long-span bridges, and towers — as well as with the new generation of very large and highly flexible wind turbines. These numerical models are typically validated through wind tunnel experiments, where the boundary layer profile and turbulence scales are modulated to realistically reproduce near-ground flow conditions. The integration between numerical modelling and experimental validation currently represents a key strategy for improving the resilience of built environments to climate-induced extreme wind phenomena. |

| | |
|---|---|
| | In parallel, particular attention is devoted to the statistical characterization of extreme wind events, which remains essential for design and risk assessment across different applications. The probabilistic analysis of wind speed extremes — through methods such as Extreme Value Theory (EVT) and peak-over-threshold approaches — provides critical input for defining design wind loads and return periods. For wind turbines, this statistical framework supports reliability-based design and fatigue assessment under rare but severe wind gusts; for large bridges, it informs aerodynamic stability and flutter limits; and for tall buildings, it guides occupant comfort, façade loading, and structural safety criteria under high-wind scenarios. |
| **Methods and techniques that will be developed and used to carry out the research** | The work will be done coupling Computational Fluid Dynamics (CFD) models with system dynamics models. The CFD framework will be open-source and a HPC infrastructure will be used.<br><br>Experimental activity will be performed to gather data suitable for the validation of the numerical models and the response of the structures.<br><br>Post-processing of CFD results will allow to gather more insight in the physical phenomenon, giving some additional information for understanding the interaction of structures with turbulent flow. |
| **Educational objectives** | Develop advanced CFD models that combine Fluid-Dynamics and System Dynamics.<br>Experimental background to have a physical understanding of the phenomenon.<br>Combine and master different modelling techniques.<br>Develop competences on innovative components.<br>Multi-disciplinary competencies.<br>Methodological competences at both the theoretical and applied level.<br>Problem setting and solving capabilities.<br>Develop team-working attitude. |

POLITECNICO DI MILANO

| | |
|---|---|
| **Job opportunities** | Wind Energy and Wind Engineering field<br>CFD specialist<br>Wind turbines aerodynamics<br>Wind turbines structural wind interaction<br>Tall building and bridge aerodynamics<br>Vehicle aerodynamics |
| **Composition of the research group** | 3 Full Professors<br>3 Associated Professors<br>2 Assistant Professors<br>5 PhD Students |
| **Name of the research directors** | Prof. Alberto Zasso |

| **Contacts** |
|---|
| For questions about scholarship/support: phd-dmec@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** | |
|---|---|
| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents** | -- |

| **Scholarship Increase for a period abroad** | |
|---|---|
| **Amount monthly** | 750.0 € |
| **By number of months** | 6 |

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops, and conferences) for a total amount of €6,114.50.

PhD candidates benefiting from this scholarship are required to spend a research period of at least 3 months abroad, joining high-level research groups in their specific research field, as agreed upon with their Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approximately €750/month – net amount). Additionally, candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3.000 to cover travel expenses.

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities related to teaching support. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.