



# PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

**PNRR 118 INTERDISC Research Field: PLANT-CONTROL CO-DESIGN OF AIRBORNE WIND  
ENERGY SYSTEMS**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1400.0**

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**

Interdisciplinary PhD Grant  
The PhD research will be carried out in collaboration with research groups of the PhD programme in "**INFORMATION TECHNOLOGY**". See <https://www.dottorato.polimi.it/?id=422&L=1> for further information.

Airborne Wind Energy (AWE) is the technology of generating wind energy with an autonomous tethered aircraft. It represents a radically new concept for wind energy conversion, deemed a potentially game-changing solution that is attracting the attention of policymakers and stakeholders, including the European Commission, with the promise of producing large amounts of cost-competitive electricity and with wide applicability worldwide. AWE technologies are the subject of research and development by several research groups and small and medium enterprises worldwide, trying to solve the technical bottlenecks that still block the way to commercialization. One such bottleneck is system reliability, where the main challenge is due to the strong interactions between system design aspects, mostly pertaining to aerodynamics, aircraft structure, and flight mechanics, and control design aspects, such as the safe switching among different flight regimes and fault-tolerant control logics. An integrated plant-control co-design of AWE systems would be required to properly address this challenge; however, no research group so far has been



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|  | <p>able to develop such an approach. The goal of this PhD project is to deliver a rigorous and effective co-design method for AWE and to test it both in high-fidelity simulations and experimentally. This objective is fully consistent with Mission 2 "Green Revolution and Ecological Transition" of the National Recovery and Resilience Plan (PNRR), particularly Component 2 "Renewable Energy, Hydrogen, Grid and Sustainable Mobility." The research is also consistent with Mission 1 "Digitization, innovation, competitiveness, culture and tourism" in its component 2 "Digitization, innovation and competitiveness of the production system" with reference to the production of innovative goods and services for energy generation.</p>  |
| <p><b>Methods and techniques that will be developed and used to carry out the research</b></p> | <p>Only an interdisciplinary research effort involving both aerospace and control engineering can successfully deliver the wanted co-design methodology. The PhD student will address the joint plant and control design for different classes of AWE systems, bringing together and deepening the expertise of the proposers. The first year will be focused on deeply understanding the aerodynamic and structural aspects of tethered aircraft, which present a completely different behaviour with respect to conventional aircraft, as well as the current state of the art in automation and control of AWE systems, and the links between AWES design and its control. Moreover, a failure mode and effects analysis for this class of systems will be carried out. In the second year, the plant-control co-design approach will be formulated and studied as an optimization problem, drawing inspiration from results obtained by one of the groups in the wind energy sector, and integrating the current aeroelastic design of wind turbines with the preliminary design of the aircraft, as recently proposed for a hybrid-electric aircraft. To concurrently optimize the plant design and its automation and control, an innovative procedure to optimally select and tune the latter will be developed, accounting for the constraints and specifications of all the operational phases (take-off, power generation, transition phases, landing) and aiming to guarantee suitably defined performance indicators of system robustness and</p> |



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|                               | <p>reliability, also considering faults and consequent recovery measures studied in the previous year. The third year will be devoted to extensive testing of the developed co-design technique, using detailed simulation suites and partly via experiments in the laboratories of the two proponents). The PhD will spend six months abroad at TU Delft, with whom the research groups have an ongoing collaboration that can be further strengthened by this project, bringing the groups to greater international visibility.</p>  |
| <b>Educational objectives</b> | <p>While developing the research, the PhD student will be required to spend time on the acquisition of highly specialized technical and personal skills oriented toward his or her future entry into the world of employment. In particular, the PhD student will be required to complete 30 credits through attendance at Doctoral level courses provided by the Politecnico di Milano both through the various Departments and through the Doctoral School itself. The choice of study plan will be made by the PhD student, giving priority to his/her specific interests and the relevance of the chosen subjects to the research work. In addition, possible collaborations with companies in the field of AWE will give the candidate the opportunity to explore the industrial world, thus expanding his or her skills outside the academic world. The figure to be trained will therefore have an excellent ability to work in the field of research and development but with a focus on the productive and industrial world of Italy and beyond. Since a strong scientific relevance of the proposed research is expected, the PhD student will be offered the possibility to publish contributions in peer-reviewed scientific journals and, if necessary, to present his/her results at Scientific Conferences in the field (EAWC PhD Seminar, TORQUE, WESC, AWEC,...). If desired, the PhD student may be involved in activities to support teaching. As is now common practice in many European projects, the PhD student's research activities will also be publicized in dissemination activities towards the public, young and adult, in the various initiatives already in place at the Politecnico di Milano (open day lab, MeetMeTonight, social channels, etc.).</p> |



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| <b>Job opportunities</b>                 | During the research project, the PhD student will acquire excellent skills inherent to the airborne and wind energy sector: since the research aims to develop methodologies that impact at the system level, and therefore touch many aspects of the operational life of the plant, the PhD student will develop solid analytical skills, in particular regarding the modelling of aerodynamic, structural, and control phenomena acting on the system. In addition, the PhD student will develop a solid understanding of the optimization techniques necessary for the development of the algorithmic part. By the end of the research, the PhD graduate will thus have developed valuable multidisciplinary skills that are typically appreciated by the various players in the relevant market. Job opportunities, however, are not limited to the Italian and international airborne wind energy sector, but also to all those industrial fields where multidisciplinary design skills and modelling and complex systems integration capabilities are required (such as classical wind energy, aeronautics, space, automotive, etc.). |
| <b>Composition of the research group</b> | 0 Full Professors<br>2 Associated Professors<br>2 Assistant Professors<br>8 PhD Students  |
| <b>Name of the research directors</b>    | Prof. Alessandro Croce & Lorenzo Fagiano  |

| <b>Contacts</b>  |
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| <b>Additional support - Financial aid per PhD student per year (gross amount)</b> |    |
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| <b>Housing - Foreign Students</b>   | -- |
| <b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>             | -- |

| <b>Scholarship Increase for a period abroad</b> |         |
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| <b>Amount monthly</b>                           | 700.0 € |
| <b>By number of months</b>                      | 6       |



| National Operational Program for Research and Innovation   |               |
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| Company where the candidate will attend the stage (name and brief description)                       |               |
| By number of months at the company   | 0             |
| Institution or company where the candidate will spend the period abroad (name and brief description) | TU Delft (NL) |
| By number of months abroad   | 6             |

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

The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.

**Premiality:**

At the end of each year, an additional bonus of up to 1600? (gross amount) per year can be achieved based on the quality of work done during the year. To obtain it, the PhD student has to demonstrate a significant contribution to the growth of scientific excellence, the industrial valorization of the research, and the networking and communication activities of the Departments involved in the research.