POLITECNICO DI MILANO

PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 41st cycle

THEMATIC Research Field: TECHNOLOGIES AND PROCESSES FOR SORBENT-BASED DIRECT AIR CAPTURE OF CO2 (DAC)

Monthly net income of PhDscholarship (max 36 months)
1600.0 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	The PhD research program, pursued in collaboration with TNO (Netherlands Organisation for applied scientific research, www.tno.nl), which funds this research, deals with the design and testing of an innovative Direct Air Capture process, based on adsorption with solids, possibly combined with other technologies (e.g., membranes). Direct air capture (DAC) is a technology designed for CO2 removal directly from the atmosphere. It is one of the Carbon Dioxide Removal technologies identified as crucial by the IPCC and the IEA for achieving Net Zero emissions. It has the potential to play a significant role in the global efforts for tackling climate change by offsetting emissions from hard to abate sectors or removing historical CO2 emissions. The main challenges for further advancing DAC technologies are the high energy-intensity and costs of the process. The underlining cause is the low concentration of CO2 in air (~0.04 vol%) which means that large volumes of air must be processed in order to capture meaningful amounts of CO2. The project is highly innovative both due to the low/medium technological maturity of the DAC processes to be investigated (both with potentially high impacts) and due to the multidiscilinary nature of the research

	involving both modelling and experimental activities. In this PhD, numerical modelling activities, aimed at supporting the design and upscaling activities, as well as to plan the test campaigns and to interpret the experimental results will be performed. Moreover, experimental testing and data reconciliation and interpretation is expected to be carried out by the PhD candidate using the test facilities available either at TNO Rijswijk (Netherlands) or at TNO Petten (Netherlands).
Methods and techniques that will be developed and used to carry out the research	The present PhD program will focus on improving the energy-efficiency of adsorption-based DAC systems. One important issue for this kind of systems is that most sorbents suffer from imperfect selectivity of carbon dioxide, meaning that besides carbon dioxide they also adsorb water. Limiting co-adsorption of water is crucial for improving the energy-efficiency of the process, as removing water molecules form the sorbent during regeneration requires substantial amounts of energy and reduces the working capacity of the adsorbent. The PhD candidate will look into water removal options with membranes and sorbents (or other processes). Besides water removal, the research question includes the potential of improving the separation efficiency (e.g. kinetic separation, sorbent texture shaping) of the DAC system. The candidate will carry out numerical modelling activities to assess the efficiency and cost of the process at a system level, propose design options for performance improvement and, perform test on both adsorption (i.e., breakthrough, ZLC) and membrane systems at the testing facilities in TNO Petten (Netherlands). Experimental data obtained will be used to validate the modelling results and provide insights into the characteristics of the process. The research will be highly inter-disciplinary, since competences in the following disciplines are required since the early stage or will be developed during

	the PhD program: energy systems design and simulation, applied thermodynamic, process modelling and techno-economic analyses, separation processes (solvent-based and sorbent-based), experimental testing (including selection and operation of scientific instrumentation). The PhD will deal with data from real plants and from models/literature. Process engineering analysis tools and software (e.g. Aspen Plus, Aspen Adsorption, gProms, Matlab, Phyton, etc.) will be used for process modelling and simulation purposes. PhD results shall be published in scientific papers, submitted to international journals, and/or presented at conferences.
Educational objectives	In the course of the PhD programme, the candidate will develop: •scientific and technical skills thanks to the guidance of experienced professors and research staff of the “Gecos” research group (www.gecos.polimi.it) and of Senior scientists and project managers at TNO (Netherlands Organisation for Applied Scientific Research). •skills in experimental testing and lab activities related to DAC technologies at laboratory scale. Testing and experimental activities will be mostly performed at TNO facilities in the Netherlands. •skills in teaching and supervision of younger students. •project management skills. •skills in the preparation of research projects proposals for competitive calls.
Job opportunities	The PhD research will qualify the candidate with skills in applied research and technology transfer in the field of process technologies, low-carbon technologies and in the sector of CCUS. In these areas, Politecnico di Milano and TNO are involved in national and international collaborative

	involved in national and international collaborative research projects in partnership with companies and other R&D institutions.
Composition of the research group	5 Full Professors 6 Associated Professors 10 Assistant Professors 25 PhD Students
Name of the research directors	Manuele Gatti and Matteo Carmelo Romano

Contacts
manuele.gatti@polimi.it matteo.romano@polimi.it Research scientists and Project Manager from TNO (which sponsored the scholarship) will act as co-supervisors.

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	800.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Increase in the scholarship for stays abroad: euro 800.00 net per month (approximately), for up to 6 months. **The abroad period can be optionally increased to 12 months upon agreement between POLIMI and TNO (in case, compensation to the PhD student either in the form of equivalent scholarship increase or reimbursement will be provided).** **Awards:** **Awards up to a cumulative amount of euro 16'000 gross for the entire PhD duration (split in different contributions among the different years)** may be granted upon achievement of satisfactory results in terms of scientific performance and contribution to side activities. More details will be provided by the supervisors/tutor and PhD school. **Educational activities:** Financial aid per PhD student is available for purchase of study books and material, funding for

participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. This amount is equal to 10% of the annual gross amount, for 3 years.

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

Computer availability:
individual use.

Desk availability:
individual use.