POLITECNICO DI MILANO

PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 40th cycle

THEMATIC Research Field: HIGH TEMPERATURE ELECTROLYSIS FOR THE DECARBONIZATION OF THE IRON AND STEEL INDUSTRY

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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 Iron and steel industry is the largest industrial greenhouse gas emitter worldwide, being responsible for about 8% of the anthropogenic CO_2 emissions. Today, most of its CO_2 emissions are generated by coal-based iron production in blast furnace-basic oxygen furnace (BF-BOF) steel mills. Options to decarbonize primary steel production include: (i) the retrofit of BF-BOF plants with CO_2 capture and storage (CCS) plants, (ii) the switch to natural gas direct reduced iron (DRI) with CCS and (iii) the switch to hydrogen-based DRI production.Steel production in electric arc furnaces (EAF) from recycled scrap (secondary steel) or from DRI, as well as the downstream steel reheating furnaces are also significant contributors to CO_2 emissions, which may be reduced via CCS, hydrogen and electrification.The overall objective of this PhD project is to perform a comparative techno-economic analysis among the different options for the reduction of CO_2 emission from the iron and steel industry, with specific focus on hydrogen produced from high-efficiency high-temperature electrolysis. The project will be developed through the following work packages (WPs): •WP1: Definition and understanding of the mass and energy balances of iron and steel production pathways through literature review and process simulations.

	through literature review and process simulations. Comparative analysis of conventional processes based on benchmark unabated processes and novel low-carbon processes based on hydrogen, CO_2 capture and electric heating. Development of models for economic analysis and techno-economic comparative analysis. •WP2: Development of models of solid oxide electrolysis cell (SOEC) systems for efficient production of hydrogen, including part-load and dynamic operations, also considering integration opportunities with the steelmaking plants. •WP3: Development of models for the calculation of balances of electrified and H_2-based plant configurations through year-long simulations with hourly resolution. Optimization of the size of the systems for energy storage and evaluation of flexibility opportunities in response to the variability of renewable electricity supply.
Methods and techniques that will be developed and used to carry out the research	The research program requires the use of the following computational tools: •Aspen Plus software, for the calculation of mass and energy balances of iron and steel plants and for the modelling of electrolysis systems and components (possibly extending to Aspen Custom Modeler where needed). •MILP optimization software (using programming language - such as Matlab, Python, or GAMS - and commercial solvers - such as cbc, Gurobi, or CPLEX) for the year-long assessment of industrial plants integrated with intermittent renewable energy supply and storage systems.
Educational objectives	The PhD candidate will: •Become expert in critically analysing the performance of

	energy conversion processes from energy, environmental, and economic points of view. •Acquire specific modelling skills on: process simulation, steady-state and dynamic simulation of electrolysis systems (stand-alone and process-integrated), optimization tools. •Become proficient user of software for process simulations (Aspen Plus) and for optimization (Matlab-Yalmip, Python-pyomo, GAMS).
Job opportunities	Apart from academia and research institutes, the main expected job opportunities after the PhD will be in consultancy and in industry (both technology providers and end users), which in the next decade will implement innovative processes and technologies to reduce their carbon footprint.
Composition of the research group	6 Full Professors 9 Associated Professors 5 Assistant Professors 40 PhD Students
Name of the research directors	Matteo Romano, Stefano Campanari,Paolo Colbertaldo

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

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
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, instrumentation 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.

Awards:
Awards will be recognized to the PhD candidate up to Euro 4000 (gross amount) per year, in case of exceptional achievements in the research project, subject to the evaluation of the research director.