POLITECNICO DI MILANO

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

Number of scholarship offered	4
Department	DIPARTIMENTO DI ENERGIA

Description of the PhD Programme

With the PhD Programme in Energy and Nuclear Science and Technology (STEN), the Department of Energy offers to graduate students a research opportunity in the following areas: production, conversion and transmission of energy, rational use of energy and environmental control, thermal science, nuclear systems and nuclear fuel cycle, radioprotection and application of ionizing radiations, methods for safety and reliability analysis and development of innovative materials for energy applications.
The PhD Programme has the objective of providing high quality training in scientific research and, as a consequence, preparing professional profiles capable of tackling the numerous activities involved in high level research, both in academia and in industry, which often requires a higher level of education than that offered by the Master of Science and Master study courses. The PhD graduate is specifically trained for leading, organizing, planning, managing and controlling research activities at high levels of international competitiveness in the field of Energy and Nuclear Science and Technology.

The department involved in the STEN PhD is the Department of Energy, which is also the administrative responsible for this PhD programme.Â

The research subjects offered by the STEN PhD Programme are listed in the relevant call.

POLITECNICO DI MILANO

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

THEMATIC Research Field: INNOVATIVE USER MODELS FOR NEW GENERATIONS DISTRICT HEATING SYSTEMS

Monthly net income of PhDscholarship (max 36 months)
€ 1700.0 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	District heating (DH) systems are considered one of the key technologies for the decarbonisation of the civil sector heat demand being an enabler of energy efficiency measures at urban level. DH can play a major role in reaching the ambitious decarbonisation targets set by the European directives by distributing renewables and waste heat recovered heat at city scale. However the planning, design and operation of these systems is not a trivial task, especially in existing contexts characterized by high temperatures operations. In addition to these, DH systems are large scale, multicomponent, complex systems composed by generation systems, long distribution networks and the building users' demand. All these elements are characterized by different thermal dynamics and temperature levels, which all impact on the overall system performances. In particular, temperature levels and peaks in the energy profile may significantly undermine the feasibility of decarbonisation strategies. To tackle this challenges, the candidate is called to develop physical based but simple models aimed at assessing feasibility of decarbonisation measures on large scale DH networks and design of new generation systems.
Methods and techniques that will be developed and used to carry out the research	Due to the complexity and extent of the DH systems, the research needs to combine different methods at different

	scale of the analysis, very local and detailed in space and time, to be included in both large scale simplified modelling tools keeping a physical significance. Main approaches foreseen are: •physical dynamic models •optimization algorithms (MLP or MILP) •data-driven methods
Educational objectives	Deep knowledge of the technology, its physical behaviour and its role in the energy system together with the ability to handle and elaborate new tools of analysis. Modelling skills and critical knowledge of the technology in the framework of urban energy system decarbonization. Critical analysis and skills in management of big dataset of monitoring data from existing systems
Job opportunities	R&D sectors of energy utilities, district heating engineering and design companies. National energy agencies and research institutes. Innovation and consulting companies.
Composition of the research group	2 Full Professors 4 Associated Professors 3 Assistant Professors 10 PhD Students
Name of the research directors	2

Contacts
Alice Dénarié: alice.denarie@polimi.it; Mario Motta: mario.motta@polimi.it; Marcello Aprile: marcello.aprile@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	850.0 €
By number of months	6

Stage and period abroad	
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	0

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities: Financial aid per PhD student is available for the purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations, computer, etc.: 6'522.50. Teaching assistantship: Availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial aid for activities to support the teaching practice. The PhD student is encouraged to participate in these activities within the limits the regulations allow. Computer availability: individual use. Desk availability: individual use. Award: Awards can be recognized to the PhD candidate up to Euro 3500,00 (gross amount, per year) in case of particular achievements in the research project, subject to the evaluation of the research directors

POLITECNICO DI MILANO

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

THEMATIC Research Field: MULTIDIMENSIONAL MODELLING OF SOLID OXIDE CELLS AND STACKS

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	Solid Oxide Cells (SOCs) are emerging as a technology with high potential impact in (i) low-CO_2 emission power generation (operating as fuel cells, SOFC) and (ii) Power-to-X applications (operating in electrolysis mode, SOEC), with the additional capability of reversibly switching between the two operating modalities and being applied for energy storage. In the first case, a novel cycle has been proposed and patented at Politecnico di Milano by the Gecos group for power generation with CO_2 capture, which includes a stack of SOFCs operated in novel conditions (pressurized up to 300 bar, with CO_2-rich oxygen supply to the cathodic side, up to 79% CO_2 molar fraction); the cycle is presently under further development in collaboration with leading companies. SOFCs are also studied for zero-carbon and high-efficiency power generation from alternative fuels such as ammonia, working in peculiar thermochemical and thermodynamic conditions. In the second case, novel cycle arrangements have been investigated for applications including the production of methanol and green ammonia, both through EU-financed projects and cooperations with industries involving the Gecos group at POLIMI. Such applications typically rely on operating the SOC in unusual and unexplored conditions from the point of view of pressure, temperature, reactant compositions, and conversion factors, requiring

	new tools for the simulation of the behaviour of solid oxide cells and stacks, being the already existing experimental activities in comparable conditions extremely scarce or absent in the scientific literature. The objective of the research is then to develop multi-dimensional models (e.g., 3D, starting from existing experience in other types of models) able to simulate the thermal and electrochemical balances and the fluid-dynamics of solid oxide cells and stacks and investigate their performance in terms of internal profiles of key variables (current density, temperature, reactant composition), to calibrate and validate the model through comparison with available experimental data in different regimes (based also on the cooperation of the proponent research group with external industries) in order to build a robust and flexible tool, and to ultimately investigate the SOC stack operation in the novel operating conditions featured by innovative power generation and power-to-X applications.
Methods and techniques that will be developed and used to carry out the research	The project will be developed through the following work packages (WPs): •WP1: Review of literature models for SOC stacks; definition of reference stack geometries and materials (cell, interconnector, gas distributor) •WP2: Preliminary 1D to 2D simulations with different simplified approaches to test and select the modelling tools •WP3: Development of a complete 3D model for a reference SOC stack •WP4: Calibration and tuning of the model with respect to different SOC stack operating conditions •WP5: Application of the model to investigate the SOC behaviour in selected innovative cycles and processes The research program requires the use of the following computational tools: •Open-source and commercial codes for multi-dimensional thermos-fluid-dynamic and electrochemical simulations (e.g., OpenFoam, Comsol).

	simulations (e.g., OpenFoam, Comsol). •Process simulation software (e.g., Aspen Plus), for the calculation of mass and energy balances of systems based on solid oxide cells (including 1D SOC models). Cooperations with the LCCP group at POLIMI and external research groups will allow to validate the model through results of experiments on SOCs.
Educational objectives	The PhD candidate will •acquire specific modelling skills and learn how to operate with state-of-the-art modelling tools for the analysis and evaluation of high temperature electrochemical components, focusing on the SOC technology; •become familiar with experiments carried out in SOC laboratories; •Become proficient user of software for process simulations (Aspen Plus); •develop individual research skills and teaming skills, including interactions with industry researchers and with other research institutions (also through an expected period abroad). The PhD candidate will join highly qualified and leading research groups, belonging to the academic field (Gecos, LCCP), as well as to the industrial field.
Job opportunities	The main expected job opportunities after the PhD will include the possibility to apply for (i) future research positions (in academia and research industries) and (ii) a highly qualified professional career in industries or organizations operating in the energy field, in particular in consultancy and 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 10 Associated Professors 5 Assistant Professors 40 PhD Students
Name of the research directors	S. Campanari, P. Colbertaldo (co-dir: A. Donazzi)

Contacts
stefano.campanari@polimi.it paolo.colbertaldo@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	800.0 €
By number of months	6

Stage and period abroad	
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	0

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 approx. 10% of the annual gross amount of the scholarship, 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. ***Awards***: Awards may 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.

POLITECNICO DI MILANO

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

OPEN SUBJECT Research Field: MULTISCALE ENERGY SYSTEM MODELLING FOR THE ENERGY TRILEMMA IN A ERA OF UNCERTAINTIES (MESYM)

Monthly net income of PhDscholarship (max 36 months)
€ 1700.0 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	In the light of the evolving challenges for the energy trilemma (security, equity and environmental sustainability) in both industrialized and emerging countries, our mission is to study sustainable pathways for the technological evolution: • adopting multi-carrier and cross-sector approaches, • intercepting the various economic implications and impacts, • deepening the global geopolitical effects on the energy transition • To provide evidence-based results and inform a solid policy making process for both industrial and public policies Quantitative assessment are key to understand the many interconnection for the Energy- (Sustainable) Development nexus is at the center in both the Agenda 2030 and the 17 Sustainable Development Goals by the UN, the EU Energy Policy, and the many national, regionals and international policies in Energy. Due to the complex and interdependent nature of such processes, an integrated and multiscale approach is currently claimed, able to model a variety of different phenomena at both small and large scales, focusing at local and global quantities.

	In line with this objective, the research aims at developing innovative and integrated modeling frameworks, using the most appropriate methodology based on the analyzed scale: - Small-scale systems (the scale of the components/plants): thermodynamic-based methods (i.e. Energy and Exergy analyses), Computational Fluid Dynamics (CFD) and Lumped Parameter Model (LPM) analyses. - Meso-scale systems (networks of productive systems): agent-based models, simulation and optimization models, planning tools. - Large-scale systems (productive sectors of countries): empirical models based on Input-Output analysis and Life Cycle Assessment. The development and joint application of these methods will enable to assess the impact of different systems, and to define suitable strategies to reduce it, hence fostering sustainable development
Methods and techniques that will be developed and used to carry out the research	Theoretical tools: Thermodynamics, Exergy based methods, LPM, CFD, Demand and Supply Side Energy modeling, Input-Output analysis, Life Cycle Assessment. Computational tools: ASPEN, Cycle-Tempo, ANSYS Fluent, OpenFOAM, Engineering Equation Solver (EES), Simapro, GAMS, Matlab, Python for energy modelling (open source approach) .
Educational objectives	The objectives are to develop/implement, verify, calibrate and validate: - integrated Multiscale Energy Systems Models, to perform economic and environmental impact assessment of industrial and productive systems; - Multiscale Thermo-Fluid Dynamic models, to perform performance assessment and optimization of industrial and productive components and sub-systems. - Decision Support System able to provide multicriteria evidence to Polity makers
Job opportunities	Energy Analyst for energy utilities and/or for NGOs and

	international organization or public institutions
Composition of the research group	2 Full Professors 4 Associated Professors 3 Assistant Professors 10 PhD Students
Name of the research directors	Emanuela Colombo, Fabio Inzoli

Contacts
emanuela.colombo@polimi.it, fabio.inzoli@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)			
	1st year	**2nd year**	**3rd year**
Housing - Foreign Students	1000.0 € per student	1000.0 € per student	1000.0 € per student
	max number of financial aid available: 1, given in order of merit ..		
Housing - Out-of-town residents	--		

Scholarship Increase for a period abroad	
Amount monthly	850.0 €
By number of months	6

Stage and period abroad	
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	0

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

Increase in the scholarship for stays abroad: euro 850 per month, for up to 6 months.

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. The amount is about Euro 7.000,00.

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.

Awards:
Awards can be recognized to the PhD candidate up to Euro 2.000,00 (gross amount, per year).
More details about this program will be provided by PhD Program Steering Committee.

POLITECNICO DI MILANO

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

THEMATIC Research Field: OTTIMIZZAZIONE DELLA COMBUSTIONE DELL'IDROGENO IN BRUCIATORI A SWIRL TRAMITE PINN E TECNICHE SPERIMENTALI AVANZATE

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	The research focuses on the development of innovative, low-emission hydrogen-fuelled burners and combustors for power generation and propulsion. The objective is to study the interaction between hydrogen combustion, fuel injection strategies, and the flow field, and how these affect flame stability and pollutant formation. To investigate these aspects, the project will rely on advanced optical diagnostics for *in situ* measurements in both reacting and non-reacting environments. These techniques will generate a detailed experimental dataset, essential for understanding the fundamental physics of hydrogen combustion. In addition to traditional modeling approaches, the research will explore the use of Physics-Informed Neural Networks (PINNs), a novel machine learning framework that incorporates physical laws—such as conservation of mass, momentum, and energy—into the training process. PINNs offer a promising path to interpret experimental results, reduce computational cost, and improve the accuracy of predictive models in complex reactive flows. The synergy between high-quality experimental data and data-driven modeling supported by physical constraints will guide the development of cleaner and more efficient combustion technologies. This integrated approach aims to advance the design of next-generation hydrogen-based systems, contributing to the broader goals of energy transition and emission reduction.

Methods and techniques that will be developed and used to carry out the research	Several optical diagnostic techniques (LDV, PDA, S-PIV, BOS, high-speed imaging, and schlieren visualization) are available at the Combustion Laboratory. Specific applications will be explored to characterize flow field structure, turbulent mixing, temperature, and species distribution in reacting and non-reacting conditions. Physics-Informed Neural Networks (PINNs) will support data interpretation and enhance modeling of complex combustion phenomena.
Educational objectives	The objectives are to deepen the understanding of thermo-fluidynamic phenomena related to combustion systems and to develop advanced skills in optical/laser diagnostics, data analysis tools, and research methodologies applied to experimental fluid mechanics and combustion systems.
Job opportunities	Candidates may have the opportunity to undertake training periods in internationally recognized research laboratories and to establish connections with industrial partners. Good prospects for postdoctoral positions in academia or industry are anticipated.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Fabio Cozzi

Contacts
Prof. Fabio Cozzi email: fabio.cozzi@polimi.it Tel. +39 02 2399 8616 Lab +39 02 2399 8610

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

POLITECNICO DI MILANO

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Stage and period abroad	
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	0

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, 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

Awards: Economic awards up to Euro 2500 (gross amount) per year will be recognized to the PhD candidate in case of significant contributions in the research project, subject to the evaluation of the research director

Computer availability: individual use.

Desk availability: individual use.