TABLE 10 – PhD Programme in ENVIRONMENTAL AND ENERGY ENGINEERING SCIENCE

THE PhD PROGRAMME	
Administrative location	University of Udine - Polytechnic Department of Engineering and Architecture (DPIA) - via delle Scienze 206, 33100 Udine, ITALY (tel. +39 0432 558253).
Associated location	-
Location for training, teaching and research activity	Teaching and other training activities will take place primarily at the administrative programme location or in other locations of the University of Udine. The research program will be mainly developed, with reference to the assigned scholarship, at one of these locations: administrative location, enterprise.
Coordinator	Prof. Alessandro Trovarelli (alessandro.trovarelli@uniud.it)
Programme duration	3 years
Curriculum	-
Course website	http://phd.diegm.uniud.it/eees-phd/

ADMISSION REQUIREMENTS	
Required degree	Italian Laurea (before DM 509/99) or Italian Laurea specialistica/magistrale (ex DM 509/1999 and DM 270/04). Foreign degrees and titles: refer to art. 3 and 4 of the Call.
Knowledge of the following foreign language	English

DOCUMENTS AND QUALIFICATIONS TO BE ATTACHED TO THE APPLICATION FOR ADMISSION	
Compulsory documents (art. 5 of the Call)	1. Certification or self-certification (refer to art. 5 paragraph 5 of the Call) of the academic title needed for admission to the PhD programme and list of the exams (with grades) passed during the Italian first level (bachelor) and the Laurea Specialistica/Magistrale programmes or during the Italian programmes before D.M. 509/99 or during the foreign academic programmes; 2. Curriculum vitae et studiorum, dated and signed; 3. Copy of a valid identity document (citizens of countries not belonging to the European Union a copy of a valid passport, comprehensive of the pages containing the holder's photo, personal details, passport number, date and place of issue, date of expiry); 4. A research project, dated and signed, developed in accordance with the description of the research topic of interest, which highlights the contribution that the applicant can offer to the development of the same topic (approximate limit 10,000 characters, spaces included, in English language).
Optional documents (art. 5 of the Call)	1. Master thesis ("Tesi di Laurea") associated to the degree/title providing access to the PhD programme. Applicants who are not graduated on the expiration date of this Call can submit an extended abstract in place of the complete thesis, in Italian or English language, signed by themselves and by their thesis Supervisor (approximate limit 10.000 characters, spaces included); 2. Motivational letter, dated and signed, by which the applicant explains the reasons for admission to the PhD programme (approximate limit 2.500 characters, spaces included); 3. Publications (max 2); 4. Letters of reference (max 2), from university professors, scientific researchers or other experts in the field (art. 6 of the Call).

SELECTION COMMITTEE	
Appointed members	Lorenzo Fedrizzi – Full Professor – University of Udine Daniele Goi – Associate Professor – University of Udine Carla de Leitenburg – Assistant Professor – University of Udine Cristian Marchioli – Associate Professor – Università di Udine Andrea Melchior – Associate Professor – Università di Udine Daniele Zuccaccia – Associate Professor – Università di Udine
Substitute members	Marilena Tolazzi – Full Professor – University of Udine Alessandro Trovarelli – Full Professor – University of Udine Alfredo Soldati – Full Professor – University of Udine Francesco Andreatta – Associate Professor – University of Udine

ADMISSION
GENERAL COMPETITION (art. 8 of the Call for Applications)

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Positions available: 7						
Detailed description	***N.***	***Funding***	***Annual gross amount***	***Period abroad***	***Period in enterprise (indentified by the Univ. of Udine)***	***Research topic***
Positions WITH SCHOLARSHIP: 7	**1**	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional (or mandatory, if foreign enterprise)	min 6 - max 12 months mandatory	1.1 Green Topic "Selective recovery of metals of technological and environmental importance from complex aqueous matrices of industrial origin" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	-	min 6 - max 12 months mandatory	1.2 Green Topic "Photodynamic disinfection of wastewater intended for reuse: biocompatible and environmental-friendly approaches " (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional (or mandatory, if foreign enterprise)	min 6 - max 12 months mandatory	1.3 Green Topic "Ecofriendly mechanochemical synthesis of supported metal catalyst innovative formulations for energy and environmental applications" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.4 Green Topic "Development of friction material with reduced emission of particulate for braking systems of electric (BEV), hybrid (HEV) and plug-in hybrid (PHEV) vehicles" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional (or mandatory, if foreign enterprise)	min 6 - max 12 months mandatory	1.5 Green Topic "Increase of Durability of low-emissions green naval engines operating with green fuels" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.6 Green Topic "Development of advanced thermo-fluid-mechanics models for the simulation of energy-efficient thermal insulation technologies" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU" (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.7 Green Topic "Innovative chemical physical processes with low environmental impact for the abatement of pollutants in solid and liquid matrices deriving from the treatment of dredging sludge" (PON RI 2014/2020 Axis IV Action IV.5)

Competition procedure and test schedule
Evaluation of qualifications and oral examination. For the evaluation of applicants' attitude for scientific research and their knowledge to develop the topic of interest, the Selection Committee can attribute up to 100 points to each applicant: max 30 points to the qualifications and max 70 points to the oral examination. The applicant is

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admitted to the interview if his/her qualifications receive at least 21 points. The oral examination is passed with at least 49 points. The applicant is eligible to the PhD programme if he/she passes the oral examination. Only for eligible applicants, the points attained in in the oral examination will be added to the points of the qualifications.
Scholarships are assigned according to the provisions of art. 10 of the Call.
DATE FOR THE PUBLICATION OF THE ADMITTED APPLICANTS TO THE INTERVIEW: within November 3, 2021
DATE FOR THE PUBLICATION OF THE FINAL RANKING LIST: within November 11, 2021

Foreign language that can be used for examination	Italian or English		
Evaluation Criteria of qualifications *During the preliminary meeting the Selection Committee may establish sub-criteria for the evaluation*	Curriculum studiorum		*10*
	Curriculum vitae		*2*
	Research Project		*6*
	Scientific publications		*2*
	Thesis/Abstract		*3*
	Letters of reference		*2*
	Motivational letter for admission to the PhD programme		*5*
Oral examination	Interview based on technical, motivational and scientific discussion.		
Calendar of the oral examination	**Date**	**November 4, 2021**	
	Time	11:00 a.m.	
	How to conduct the examination	The oral examination will be held online (MS Teams)	
	Based on the number of applicants, the oral examination may take place in more than one day. Applicants must exhibit a valid ID.		

Research Topics Description

Research topic 1.1: Selective recovery of metals of technological and environmental importance from complex aqueous matrices of industrial origin

Critical Raw Materials (CRM) required by industry are largely dependent from imports and have specific characteristics of non-substitutability in the short term and vulnerability along the supply chain. Among the chemical elements considered high risk, there are various metals: rare earths (REE), platinum group metals (PGM), and others (eg. Mg, Co, Sc, Sr, Nb). To recycle a metal from a liquid phase, for example resulting from the dissolution of the materials constituting end-of-life devices (magnets, electronics, energy materials, ...), it is necessary to selectively transfer it to a second phase for the subsequent recovery. The aim of the research is to generate new chemical knowledge necessary for the recycling of materials that can be exploited in a circular economy, while avoiding their dispersion into the environment and therefore the potential harmful effects. Specifically, we will focus on the recovery of rare earths (lanthanides, generally present in water as trivalent ions Ln (III)), given the particular interest in their applications in hi-tech sectors and the potential high supply risk (classified "very high risk "in the EC report https://ec.europa.eu/docsroom/documents/42881).
The expected results will consist in obtaining the thermodynamic (speciation) and structural properties relating both to the REEs in the starting solutions, and to their partition in the "receiving" phase to determine efficiency, selectivity with respect to other metals and optimal operating conditions.
In the research activity, the doctoral student will learn and apply both the techniques for the study of thermodynamics in solution (potentiometry, calorimetry, spectrophotometry) and the tools for analyzing experimental data.
In this way, it will be possible to obtain a “shapshot” of the chemical species present in the aqueous solution from which it is intended to separate the metals. The complementary structural information will be obtained, both through the skills of the group (molecular simulations conducted through the use of HPC systems) and through active collaborations with other groups (e.g. emission spectroscopy, XAS, ...).
The study of the separation process will take place through techniques such as calorimetry, spectrophotometry, ICP-MS analysis to define the separative capacity, process selectivity and effect of environmental conditions (e.g. pH or temperature).
As regards the RTILs, the characterization of the species in these media will be carried out to know the chemical form in which the CRMs have been separated. During the secondment in the company (6 months) the student will learn how to design a reactor for metal separation and define the operating parameters.

Research topic 1.2: Photodynamic disinfection of wastewater intended for reuse: biocompatible and environmental-friendly approaches

Due to water scarcity, it is necessary to develop a proper water management system that includes innovative low-impact technologies. Among the most critical aspects limiting water reuse, microbiological contamination plays a fundamental role as microorganisms can cause disease in humans and animals. Chlorination is one of the most used disinfection methods in water treatment, however, its toxicity is widely known. In consideration of these premises, it is necessary to develop and implement processes that make it possible to reduce or eliminate the use and generation of substances dangerous for human health and the environment in the face of adequate antimicrobial efficacy on wastewater.
Photodynamic inactivation (PDI) is a technique in which light activates oxygen normally dissolved in water, transforming it into an effective antimicrobial agent. PDI exploits the photodynamic effect in which a molecule, called photosensitizer (PS), is activated by light of a suitable wavelength (usually visible) to generate reactive oxygen species (ROS) extremely aggressive towards pathogens. The idea of applying PDI as a sustainable and low-impact treatment requires the immobilization of the PS on an inert solid support, to avoid its dispersion. The coupling of different techniques in association with PDI could synergistically amplify the antimicrobial effect.
The activities proposed are:
i. identification of PS of natural origin present in industrial processing waste
ii. identification of materials to be used as inert solid supports to immobilize PS

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iii. identification of molecules of natural origin to be used, in association with the selected PS, to broaden the spectrum of action of the final materials
iv. synthesis of new photoactive materials
v. determination of the effectiveness of new materials in conditions of solar radiation
vi. verification of the effectiveness of the PDI protocol, possibly in association with other non-chemical disinfectant approaches (e.g., UV, ultrasound)
vii. development of a bench-top system for the treatment of wastewater
viii. study of the sustainability of the process in the scaling-up phase.
The activity to be carried out in the company will concern the design and development of a pilot plant for the photodynamic treatment of water, as well as the verification of efficiency in the field. In addition to the activities, the PhD student will be actively involved in the evaluation of feasibility and sustainability on a full scale of the developed process.

Research topic 1.3: Ecofriendly mechanochemical synthesis of supported metal catalyst innovative formulations for energy and environmental applications
The research proposal, to be carried out during the 3 years of PhD program, is aimed at (i) preparing novel catalytic formulations by mechanochemical synthesis, (ii) application of the materials at specific reactions with energetic and environmental impact, (iii) transfer of the lab scale results to pilot scale setup in collaboration with the partner company. The selected target reactions are methane total oxidation, CO2 hydrogenation and direct methane selective oxidation to methanol. For these reactions, different catalysts will be prepared, mainly comprised into two groups: oxide supported metal catalysts (where the active metal could be Pd, Cu, Rh, Ni, Ru) and perovskites (general formula ABO3), or metal substituted perovskites. All catalyst formulations will be prepared by dry mechanochemical synthesis to enhance the overall sustainability of the research, starting from the state-of-the-art Pd/CeO2 catalysts already prepared at Uniud. After preparation, the materials will be characterized by x-ray diffraction analysis, surface area measurements and temperature programmed oxidation and reduction to determine their main physical-chemical properties. Further characterization will be carried out by Raman and infrared spectroscopy. The catalytic activity of the materials in powder form will be tested in a lab scale setup opportunely realized, whereas the in situ DRIFT and Raman spectroscopy will be used to study the reaction mechanism and the modification occurring on the catalysts during reaction. In the catalytic tests, also the resistance to the main poisoning agents (SO2, H2O, O2 depending on the reaction) will be evaluated. Thanks to international collaborations, it will be possible to carry out a deeper material characterization by high resolution transmission electron microscopy and x-ray photoelectron spectroscopy on the most promising formulations. The same formulations will be prepared in higher amount to be tested in the pilot scale setup in collaboration with the partner company. This will require also the scale up of the synthesis, and the tuning of materials mechanical properties (if to be used in pellet form) and physical chemical compatibility with the slurry if to be coated on monoliths. The exchange with the partner company will involve also suggestion for cheaper components and different metal salt precursors based on their cost and eco sustainability. The PhD student will be involved in writing scientific papers and in presenting the main results to national and international meetings.

Research topic 1.4: Development of friction material with reduced emission of particulate for braking systems of electric (BEV), hybrid (HEV) and plug-in hybrid (PHEV) vehicles
This project targets the development of eco-compatible friction materials for application in braking systems of electric (BEV), hybrid (HEV) and plug-in hybrid (PHEV) vehicles. Wear and abrasion of friction materials during braking is an important source of non exhaust particle emissions (PM) since this can contribute up to 21% of PM10 emissions on roads. Moreover, friction materials often contain heavy metals (Cu and Zn), which could be released in the environment during braking. The project targets specifically the application in BEV, HEV and PHEV vehicles since the friction material in their braking system requires specific properties as compared to traditional vehicles. In particular, degradation phenomena due to wear and corrosion in the braking system (rotor materials) will be specifically targeted in the project.
The main expected results of the research activity are as follows:
1. Development and optimization of friction material with reduced release of PM and heavy metals (Cu and Zn);
2. Introduction of corrosion inhibitors in the friction materials to control corrosion related issues in the braking system;
3. Determination of the main degradation mechanism of the new materials developed in the project.
The research approach includes the following steps:
- Characterization of raw materials and formulation of innovative eco-compatible friction materials
- Investigation of durability of the new friction materials (wear tests and stiction tests)
- Evaluation of PM released by friction materials
- Assessment of the performance of the friction materials
The research will be carried out in the laboratories of the Polytechnic department of engineering and architecture of the University of Udine. The researcher will be hosted in the enterprise for a period of 6 months. An additional research period of 6 months is foreseen in other institutions/universities.
The researcher will develop specific knowledge in the following fields:
- Eco-compatible friction materials
- Braking systems of BEV, HEV, PHEV vehicles
- Characterization of microstructure, functional properties and durability of innovative eco-compatible materials
Wear mechanisms affecting durability of the braking system and release of PM and heavy metals

Research topic 1.5: Increase of Durability of low-emissions green naval engines operating with green fuels
Currently, the naval engines are operating with petroleum based fuels that are not environmental friendly. To decrease the environmental impact of these ships, innovative engines that operates with green fuels (ammonia, hydrogen, methanol, methane, Natural gas) are designed. The issues related to materials used to produce these engines are related to the fast degradation of some structural components (as exhaust valves) due to fatigue, wear or corrosion (wet/hot). This fast degradation can lead an increase of maintenance cost of engines. The main aim of this project is to determine the main degradation mechanisms that can cause the fast degradation of the engine' structural components. This first part of the study

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is necessary to select accurately the possible alternative materials to increase the in service life of the studied components, focusing the attention on surface engineering. To reach this goal, a collaboration between university and industry is necessary to increase the knowledge of the researcher.
The main activities of the researcher will be:
- Study of the state of the art on materials used for the critical components of the engines;
- Find innovative surface treatments of Ni and Fe based alloys;
- Characterize the selected material in laboratory scale;
- Possible scaling up of studied surface treatments on real engines;

The scientific goal of the research is to use the innovative surface treatments on low-emissions engines components that undergo to fast degradation, by increasing also the knowledge of the researcher in these fields.

Research topic 1.6: Development of advanced thermo-fluid-mechanics models for the simulation of energy-efficient thermal insulation technologies
The research activity targeted in this project is aimed at developing innovative solutions suitable for air conditioning indoor civil and industrial environments with the exclusive use of renewable energy. A possible climate control strategy is for example achieved by using phase change active insulating materials, which are capable of changing phase according to their own thermophysical characteristics and on the basis of the internal and external temperature. Phase change insulators are used in combination with passive insulating materials, selected to meet international decarbonisation goals.
The main objective is to develop models for the multiphase thermo-fluid dynamics simulation of the air conditioning process by means of active thermal insulation, with particular attention to the thermal exchanges that characterize it. The result will be twofold: on the one hand, a numerical tool will be made available for the prediction of important observables such as the temperature and velocity maps of the fluids used, the steady-state and transient heat exchanges: on the other hand, the fluid-dynamic parameters that they regulate the process and the main optimization criteria.
One of the systems that will be analyzed in collaboration with the industrial partner is based on the use of paneling elements, connected via a hydronic system to the external source to power the exchange elements, to make up the air conditioning system. The exchange system operates at temperatures very close to the internal environment, thus constituting a very high thermal barrier. In case of opportunity, the excess heat captured by the barrier contributes to the overall heat balance.
The methodology used will be mainly numerical, combining a proprietary computational code based on a diffuse-interface method (which is best-suited for carrying out the fundamental research analyses of the project), and a finite-element computational code (which is best-suited for carrying out the applied research analyses of the project and therefore for being used in an industrial context). The numerical part of the research will be validated through experimental measurements made available by the industrial partner involved in the project. The methodology chosen will facilitate the dissemination of an approach open to innovation and will encourage the transfer of knowledge between academia and industry. This exchange will leverage on the training of the ESR, who will be equipped with the physical-mathematical and computational skills required to extend the use of the simulation tools that will be developed in an industrial context.

Research topic 1.7: Innovative chemical physical processes with low environmental impact for the abatement of pollutants in solid and liquid matrices deriving from the treatment of dredging sludge
The project aims to develop a sustainable process for the treatment of dredging sludge to obtain secondary products. In particular, we want to modify the present process line for the liquid and solid matrices by developing innovative and low environmental impact chemical / physical processes (use of green chemicals and eco-sustainable processes). Therefore, we will work on two types of different matrices: on the one hand to the recovery and reuse as a secondary product of the solid matrix (valorization of the waste), on the other hand, we will modify the wastewater treatment.
The first phase of the project will concern the extensive characterization of the matrices (solid and liquid) using conventional techniques for the determination and quantification of the organic and inorganic components (ICP-MS, GC-MS, NMR, etc.) taking advantage of facilities and laboratory of both partners.
A detailed study of the process variables and the treatments/chemicals used will allow us to evaluate the best treatment in terms of its eco-sustainability and the compliance of each matrix with the legislative limits.
We want also to train a young researcher with solid theoretical-applicative skills and with important interconnections between the academic and the industrial world.
Expected results:
1) Development of an innovative treatment process with the use of green chemicals at a lab scale
2) Evaluation of the efficiency of the treatment process on real solid and liquid matrices
3) Evaluation of the possible scale up of the developed treatment processes
Methods:
1) Development of innovative catalytic materials for the treatment of solid and liquid matrices
2) Extensive characterization of the matrices
3) Morphological and structural characterization of the investigated materials
4) Evaluation of removal of pollutants from solid and liquid samples