

DOCTORATE RESEARCH PROGRAMMES ON SUSTAINABILITY / INNOVATION-RELATED
TOPICS Attachment 1

PhD PROGRAMME IN MECHANICAL AND MANAGEMENT ENGINEERING
XXXVII CYCLE

Department: Department of Mechanics, Mathematics and Management

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Places available

- “Innovation” macro-area: 2 places
- “Sustainability” macro-area: 4 places

Candidates are advised that there are separate application calls for each macro-area. Candidates who intend to apply for both programmes must submit two different applications for each macro-area.

The current document includes attachments regarding specific details for research topic fields for each macro-area.

Admission Requirements

Applicants to the PhD programme in Mechanical and Management Engineering must hold a second level (specialized) degree as follows:

- Degree diploma awarded by an Italian university prior to Ministerial Decree 509/99;
- Specialist Degree (as per Ministerial Decree 509/99);
- Master’s Degree (as per Ministerial Decree 270/04);
- Degree qualifications awarded by foreign universities officially recognised as equivalent to the above.

The Selection Board will decide upon the eligibility of qualifications as part of the qualification assessment procedure.

Application Instructions:

Please note that the information provided in this paragraph **complements and does not substitute** that contained in arts. 2 and 3 of the Call for Applications document.

REQUIRED DOCUMENTATION

Candidates **must** upload the following documentation to their online application. **Failure to do so will result in their exclusion from the selection procedure:**

1. A **CV** following the layout of the **example** provided by Politecnico di Bari on the Politecnico website www.poliba.it in the *Ricerca/Dottorati di Ricerca* section. This file should be named “01.CV”
2. A **signed, valid identification document**. This file should be named “02.Documento riconoscimento”. **Only the following documents will be considered; failure to comply will result in exclusion from the selection process;**
 - ID cards, only if issued by an EU member state;
 - Driving licence, only if issued by an EU member state;
 - In all other cases, a fully valid passport (also non-EU citizens, including the UK).
3. **Degree qualification certification for first (Bachelor) degrees and second (specialization/Master’s) degrees (or 5-year Single Cycle degrees)**. A list of all exams taken with their relative marks in both degree courses (or the Single Cycle course) should also be included,

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following the example provided by Politecnico di Bari which is available from the Politecnico website in the *Ricerca/Dottorati di Ricerca* section. This file should be named "03.Titoli di laurea".

Candidates with a **degree qualification awarded by a non-Italian university** must attach the following documents to their application, prepared by the academic institute which issued them. This supersedes any form of self-declaration:

- Degree certificate or diploma showing relative final mark;
- Official transcript of exams taken during all university study programmes, showing relative results;
- Any other relevant documentation which demonstrates the equivalence of qualifications with those required in this application call (Supplementary Diploma, *Dichiarazione di Valore* (statement of value) issued locally).

These documents must be in Italian, French or English or translated into Italian or English and verified by an official Italian diplomatic or consular representative under the responsibility of the candidate. These should follow the guidelines set out in the document "*PROCEDURES FOR ENTRY, RESIDENCY AND ENROLMENT OF INTERNATIONAL STUDENTS AND THE RESPECTIVE RECOGNITION OF QUALIFICATIONS, FOR HIGHER EDUCATION COURSES IN ITALY FOR THE ACADEMIC YEAR 2021/22*" available at the link www.studiare-in-italia.it/studentistranieri;

4. **A summary of the thesis topic for specialist/Master's degree (or five-year Single Cycle degree)**, stating the title and name of thesis supervisor(s) (max 3,000 characters); this file should be named "04.Abstract tesi";
5. **Research project proposal**, which must be completed in the format provided by the Politecnico di Bari; this is available at www.poliba.it/it/dottorati-di-ricerca. The proposal must include:
 - research project criteria in line with art.3 of Ministerial Decree 16061/2021 and art.5 of the call for applications document;
 - research topics in accordance with the PhD programme selected and relevant macro-area topic (Sustainability/Innovation, refer to attached macro-area details).

Proposals are assessed purely as part of the selection procedure and are not necessarily those which candidates will develop during the programme. This file should be named "05.Proposta di Ricerca".

OPTIONAL DOCUMENTATION

6. **A self-certification declaration for any other qualification deemed suitable for evaluation** which must be signed and dated and follow the layout of the example provided by Politecnico di Bari on the Politecnico website www.poliba.it in the *Ricerca/Dottorati di Ricerca* section. In accordance with art. 46 (Statements in lieu of Certification) and art. 47 (Self-Drafted Affidavits) of Presidential Decree 445/2000 (pursuant to art. 15 of Stability Law 183/2011), candidates may not submit certificates and affidavits issued by public administrations or providers of public services for qualifications that are to be assessed. These certificates should be replaced by statements as per arts. 46 and 47 of Presidential Decree n. 445/2000). This file should be named "06. Dichiarazione altri titoli".
7. (Additional, optional) **Two letters of presentation from teaching staff** who have supervised the candidate during their university studies. These files should be named "07.Lettere presentazione 1" and "07.Lettere presentazione 2".
8. **Language certification** demonstrating a knowledge of English which corresponds to at least B2 level. Only non-Italian citizens may attach certification which demonstrates knowledge of the Italian language. This file should be named "08.Certificazione linguistica 1" (2, 3 etc);
9. **Any publications** related to activity carried out and shown on the candidate's CV. This file should be named "9. Pubblicazione 1" (2, 3 etc.).

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All of the aforementioned documents must be in either Italian or English or translated into Italian or English, under the responsibility of the applicant.

In cases of large documents unavailable as electronic files or which exceed the number of MB permitted for documents, applicants may submit these separately (in paper format or as a CD or DVD-ROM), accompanied by a detailed list of contents, by 2 p.m. of the deadline date for admission applications.

Any publications submitted on paper or digital support must be sent in a closed envelope, signed along the seal, to the following address:

Magnifico Rettore del Politecnico di Bari – Direzione Gestione Risorse e Servizi Istituzionali- Settore Ricerca, Relazioni Internazionali e Post-Lauream - Ufficio Protocollo – Via Amendola 126/B, 70126 BARI (Italy)

Envelopes must display the name and surname of the candidate together with the following text: “*Concorso di Ammissione al Corso di Dottorato in...* (name of the PhD programme)”. The delivery of the envelope containing publications to Politecnico di Bari - by postal service, private courier or shipping agency – is at the exclusive risk of the candidate.

Admission examination

The admission examination is based on:

1. **an assessment of qualifications held** (average exam marks, final degree mark, theses, Master’s degrees, post-graduate courses, language certification, publications, etc.);
2. **an interview** to ensure a complete evaluation of the candidate and to verify the applicant’s aptitude for research and willingness to undertake experience abroad, as well as areas of research interest.

The Selection Board will assess candidates’ qualifications and interview with a mark out of 100 (maximum mark for qualifications 40 and interview 60).

The results of the Board’s assessment for qualifications and project proposals will be published on the ESSE3 portal in the private area of each candidate.

No other notification will be sent directly to candidates.

At the end of the examination procedure, the Board will carry out an overall assessment and draw up an admission rankings list on the basis of the marks obtained by candidates in each part of the examination.

The assessment criteria for qualifications will be established by each Selection Board.

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National Operational Programme 2014-2020 PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

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A. RESEARCH PROPOSAL

COLLECTIVE MOBILITY OF METROPOLITAN AREAS WITH HYDROGEN-POWERED BUSES

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as;

- protection of the ecosystem;**
- biodiversity;**
- reduction of climate change impact;**
- enhancement of sustainable development**

in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.

The decarbonisation of the energy, industry and transport sectors is one of the main objectives that most countries in the world (including Italy) want to achieve in the short and long term, in order to reduce the environmental impact and be able to safeguard the planet from the threats of the climate change. In this scenario, the only production of electricity through renewable sources does not guarantee the full achievement of this objective, in addition to the fact that renewable sources are intermittent and unpredictable. For this reason, the storage and subsequent use of the energy overproduced at peak times, which cannot be used directly, can be instrumental in making non-programmable renewable sources a crucial means to reduce emissions of greenhouse agents. Furthermore, the potential use of hydrogen as an energy vector storing the energy produced can become decisive in numerous fields of application, especially if these are made operational effectively and promptly. In any case, it is essential to foster a higher production rate of green hydrogen shortly,

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	<p>in addition to simultaneously define and implement the technologies of storage, transportation and use of hydrogen, thus allowing the rapid increase in its demand. Also, the contribution of research and development and, above all, the economic commitment that the public sector will offer in this field will be fundamental to speed up this transition phase towards the use of hydrogen on a large scale. In possible scenarios, the idea with the greatest chance of rapid implementation is the creation of hydrogen mobility, provided that a supply network that implements transportability and storage is devised. Note that the time to achieve this may depend on the strategies used to disseminate these technologies. A realistic hypothesis is to concentrate research efforts on collective mobility scenarios in metropolitan areas by means of hydrogen-powered buses. In other words, it is a question of studying mobility solutions for city buses, or even bus lines with circular routes, powered by hydrogen, which therefore do not require a capillary hydrogen distribution network. The scenario thought for a PhD student's research activity is definitely consistent with current european and national programs. Indeed, the proposed hydrogen mobility would lead to a mitigation of the climate change, given the reduction of CO2 emissions, and would certainly contribute to the promotion of sustainable development.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.</p>	<p>The research topic, as previously mentioned, will be the study of systems capable of allowing the collective mobility of metropolitan areas to be achieved by means of buses powered by hydrogen. Certainly, this purpose requires important insights into different technologies, which are not fully mature to ensure its feasibility. There are problems related to the hydrogen transportation, distribution and storage on vehicles, as well as the direct use of hydrogen, either through direct combustion (hypothesis that would not radically modify current vehicles) or through fuel cells and electric motors (hypothesis with a high economic impact on local administrations). Research activities in these areas, aimed at reducing the time of technology transfer, are also consistent with the objectives planned by the National Research Program (PNR) and the National Strategy of Smart Specialization (SNSI),</p>

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	<p>which define programs and actions to promote high specialization and to ensure coherence and rapid transferability of research.</p>
<p>c. Research activity proposal, methods and contents</p>	<p>The construction of high-tech infrastructures (Hydrogen demo Valley) is underway to test different technologies for the production, storage, distribution and use of hydrogen, to be taken pure or mixed with natural gas, for applications in the energy, industry and transport sectors. Studies and experimental activities will be conducted on the hydrogen supply chain linked to the mobility sector, including distribution systems (such as hydrogen refuelling stations), on ground and on-board storage systems, as well as on buses (either with the internal combustion engine fuelled by pure hydrogen and hydrogen-methane mixtures, or with fuel cells). These skills will allow the doctoral student to carry out the activities necessary for understanding the most suitable technologies to achieve the project's goals, especially with reference to the hydrogen transportation and storage techniques. In the laboratories of the Polytechnic university of Bari, activities will be carried out to figure out the applications in which the direct combustion of hydrogen in internal combustion engines is applicable, and those in which it is necessary to have electric propulsion with fuel cells or with mini gas turbines. The activities will be conducted numerically, through the use of commercially available calculation codes, to evaluate the costs arising from the different conversion efficiencies.</p>
<p>B. COMPANY-BASED ACTIVITIES within the Italian territory</p>	
<p>a. Research activity to carry out with the company</p>	<p>The company will allow carrying out the activities concerning the design of devices for enabling changes in buses. The partner operates in the industrial innovation sector, and designs and manufactures tailor-made products related to the environment, energy, chemical industry and mechatronic systems, with R&D services including feasibility studies, industrial research, construction and testing of prototypes and test</p>

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	<p>benches. This will allow the PhD student to find adequate support for his research project and pursue the project objectives.</p> <p>The design of the components for vehicles will be supported by advanced CAD and CAE systems; the main objectives will be:</p> <ul style="list-style-type: none"> - the identification of solutions applicable to a vehicle (also in terms of internal spaces for the allocation of the equipment); - the reduction of production costs; - to prevent operating problems and component failure; - to ensure the correct operation of the system components; - to identify risks and weaknesses.
<p>b. Period of company-based study and research</p>	<p>6 months</p>
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>The process of assessment and measurement of the results will be performed through the following actions:</p> <ul style="list-style-type: none"> - through a website of the PhD research project showing the final open access papers presented at workshops and conferences or published in journals. On the website, one will also find information on the project, project units and meetings held and planned. Monitoring the web site traffic will be a check on the success of the actions. - through workshops and meetings, as well as presentations given at national and international conferences where the results of the project will be described publicly. On such occasions, it will be possible to verify the consistency of the ongoing actions in relation to the objectives, and to address specific thematic studies also through the participation of Italian and foreign experts not directly involved in the PhD topic; the collection of useful feedback for further development and improvement will constitute a measure of the expected results; - through the promotion of a special issue in a journal indexed in the Scopus and Web of Science databases where the student can publish the research products, in order to measure the attractiveness of this topic in the scientific and institutional community.

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	Furthermore, in order to follow the indications of REACT-EU, the action will foster the involvement of representatives of institutions, districts and clusters, as well as aggregations and associations interested in the topics of the project.
C. ACTIVITIES ABROAD	
a. Research activity abroad	This collaboration will benefit from the experience of the foreign national research center gained thanks to the numerous research contracts that this university has done with important companies in this sector. The activity that will be carried out will be related to injection systems of internal combustion engines fuelled with hydrogen.

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SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

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A. RESEARCH PROPOSAL

Study of injection and combustion processes in hydrogen fueled internal combustion engines.

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as;

- protection of the ecosystem;**
 - biodiversity;**
 - reduction of climate change impact;**
 - enhancement of sustainable development**
- in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.**

The transportation sector makes a significant contribution (around 27%) to greenhouse gas emissions in the EU and therefore the climate neutrality objectives must necessarily involve reducing the use of fossil fuels for transport. The national and European hydrogen strategy aims at a broad use of green hydrogen in transport. In particular, hydrogen can make a significant contribution to greenhouse gas-free solutions for heavy road transport (commercial vehicles and buses) and off-road applications (construction/ agricultural machinery). The shipping sector, which has so far been characterized by the use of fossil fuels, must also necessarily be affected by a transition to environmental sustainability through the use of green fuels such as hydrogen. In addition to fuel cells, the use of hydrogen as unique fuel is very promising in internal combustion engines. Hydrogen-powered internal combustion engines (H₂-ICE, Hydrogen Internal Combustion Engines) can take advantage of

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	<p>many of the existing engine technologies and provide a zero emission option, while supporting the growth of hydrogen infrastructures. In particular, many applications that require high power and prolonged use (heavy commercial vehicles, earthmoving machines, naval propulsion systems) are not compatible with pure electric mobility (via BEV, Battery Electric Vehicles) for many reasons related to battery weight and charging technologies. Even hybrid fuel cell vehicles (FCEV, Fuel Cell Electric Vehicles) have some limitations related to weights and dimensions, as well as issues related in general to their reliability over time. All these problems are more easily overcome by the use of internal combustion engines powered by hydrogen. The availability of reliable, environmentally-neutral means of transport in the well-to-wheel transformation from the energy source to the wheels, will greatly encourage the development of products and services aimed at the realization of hydrogen distribution networks, giving an enormous stimulus to the development of the sector and also to less mature technologies such as FCEVs. The PhD course, which will be carried out in close collaboration with the BOSCH-CVIT center, with whom multi-year collaborations are currently already ongoing, will focus on the study of the combustion process in commercial vehicle engines powered by hydrogen using direct injection technologies, in order to reduce the problems encountered so far on the regularity of the combustion process. The doctorate will be able to contribute to the development of emerging technologies in the field of hydrogen, with particular reference to the adaptation of automotive components.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects. .</p>	<p>The theme of the Phd course project is aimed at the development of hydrogen-powered engines for use on commercial vehicles and also engines for naval transport. The project is therefore part of one of the major areas of research and innovation of PNR 2021-27 on the issues "Climate, energy, sustainable mobility", in coherence with the EU policies "European Green Deal" and the cluster 5 Climate, Energy and Mobility of Horizon Europee which is dedicated to the integrated development of solutions for the production, use and sustainable storage of energy, both in the consolidated carriers (electricity, natural gas) and in the most innovative ones (especially hydrogen).</p>

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	<p>The development of technologies for hydrogen powered engines may have as its consequences the birth and growth of infrastructures for the distribution of hydrogen as an energy carrier, so far limited to some pilot plants.</p> <p>The impact of research will make a significant contribution to progress towards climate neutrality, decarbonisation and zero pollution of all mobility and transport technologies (air, shipping, rail, road, heavy goods vehicles and off-roads);</p>
<p>c. Research activity proposal, methods and contents</p>	<p>The scientific objective is the development of knowledge and models for direct hydrogen injection and mixtures formation for a lean and turbulent combustion. The technical objective is to transfer scientific results to engine applications (mainly commercial vehicles).</p> <p>Experimental and theoretical / numerical works are closely related throughout the task.</p> <p>In summary, research can make a significant contribution to the use of H₂ in CO₂-free engine transport.</p> <p>Identification of optimum air-hydrogen mixture characteristics in internal combustion engines through the use of CFD simulations in order to maximise combustion stability and efficiency. The main objective of the activity is the identification of the best way of mixing between the fuel (hydrogen) and the air, to achieve maximum efficiency and stability from the combustion process.</p> <p>The study will be conducted both numerically, through simulations aimed at improving the process of mixing air-fuel, both experimental tests that can be carried out at the same Bosch or at the foreign university partner</p>
<p>B. COMPANY-BASED ACTIVITIES within the Italian territory</p>	
<p>a. Research activity to carry out with the company</p>	<p>Method validation: study and validation of the CFD methodology to be adopted to perform effective coupling between flow simulation within the injector and the one inside the combustion chamber.</p> <p>Numerical study of the influence of injection parameters and their impact on the formation of the mixture with the application of the DEO (Design Of Experiment):</p> <ul style="list-style-type: none"> • Injector position (central or lateral) • Variation in spray shape • Injection strategy (number of injections, pressure, timing)

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	<ul style="list-style-type: none"> • Geometry of combustion chamber and intake ducts • Influence of chamber motions (tumble/swirl)
b. Period of company-based study and research	12 months
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>The project focuses on the creation of innovative knowledge in the field of the use of hydrogen in the propulsion of commercial vehicles. This study is linked to the development of new generations of engines with significant scientific, social and economic impacts on the national territory. In particular, the research project can contribute to actions aimed at the creation of a chain operating in the field of hydrogen internal combustion engines that can contribute significantly to the achievement of the objectives of decarbonisation in the sector of transportations. In addition, it will also safeguard jobs, because it will allow the enhancement of the specializations of mechanics and mechatronics in Italian industry. This project therefore seems perfectly consistent with the aims of the plan "Recovery Assistance for Cohesion and the Territories of Europe initiative, REACT-EU", which provides part of the resources of the EU Recovery Plan - Next Generation EU for the development of green projects and digital infrastructure. As seen in section A.b, the project complies with the SNSI and the PNR, and is consistent with the L.240/2010 and the DM 45/2013 in the field of doctorates, having regard to the growing need to foster innovation and the interchange between the world of research and the productive world and the contribution of research projects in the fields of innovation (L. 240/2010, art. 24, co. 3 and ss.mm.ii.</p>
C. ACTIVITIES ABROAD	
a. Research activity abroad	<p>The activity will be mainly focused on experimental tests conducted on single-cylinder research, with numerous experimental test benches. The focus will be on developing numerical models for the hydrogen injection and mixing process.</p>

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INNOVATION-BASED TOPICS (ACTION IV.4)

SCHOLARSHIP N. 19

A. Research Proposal

Multiphysics and digital twin modeling for multi-material laser welding and additive manufacturing products

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and the formation of professional profiles as a response to the requirements of the business sector for innovation and competitiveness.

A development of research on topics of innovation, digital advancement and enabling technology while supporting the enhancement of human capital, determining factors in the progress of research and innovation in Italy.

Dissimilar materials welding refers to the welding process of two or more materials with different chemical composition, metallographic structure and performance under certain technological conditions.

The manufacture of laser beam techniques products involves the understanding of complex physical phenomena, as laser-matter interaction, that not only requires in-depth knowledge of optics, materials, sensors and the laser photons to material thermal energy transfer, but also the ability to manage and/or adapt mathematical models, which are able to predict the effects of processing and any corrective actions to avoid defects and processing waste.

Therefore, the proposed doctoral project aims to train an expert figure able to explore the laser welding of dissimilar materials problems through the modern and powerful tools of numerical simulation and machine learning

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	<p>integrated with physical experimentation and chemical and mechanical characterization.</p> <p>The multidisciplinary nature of the proposed training project will ensure that the student can enrich his knowledge in the innovative and enabling technologies field of mechanics, materials and computer science applied to industry. The overall view that will result from the study planned during the 36 months of the doctorate will then be aimed at setting up a digital twin of the laser welding process.</p> <p>Le competenze e conoscenze tecnico-scientifiche acquisite dalla figura professionale, risultante dal progetto formativo proposto, permetteranno di svolgere tanto compiti di studio e ricerca quanto quelli di ingegnere della produzione o della qualità per prodotti multimateriale ottenuti mediante lavorazioni al fascio laser.</p> <p>The technical-scientific skills and knowledge acquired by the professional figure, resulting from the proposed training project, will allow to carry out not only study and research activities, but also production or quality engineer tasks for multi-material products obtained through laser beam processing.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students, with the aim of fostering innovation and exchange between the field of research and world of manufacturing and the certification of research project contributions within the sector of innovation (Law 240/2010, art. 24, section 3 and subsequent modifications and additions)..</p>	<p>Products made from dissimilar metals and alloys are widely used in the miniaturization of consumer electronic devices, in order to optimize product performance. In newly developed microelectronic devices and batteries are used special shaped metal joints, made with high reflectivity and good electrical and thermal properties metals, such as copper and aluminum. In the aerospace sector, laser welding speeds up the process and, at the same time, allows to obtain joints with a higher quality than traditional techniques. A recent development, called laser welding with "wobbling" technique, allows to have an accurate management of the heat input and has been selected as the most promising solution to prevent manufacturing defects.</p>

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	<p>Even the Oil and Biomedical sectors benefit from the precision and reliability of laser welding of materials that are difficult to weld. Therefore, the proposed training project themes fully fall within the thematic area of intelligent and sustainable industry, energy and environment of the National Strategy of Intelligent Specialization (SNSI). They concern innovative production processes with high efficiency and expected industrial sustainability. The issues of the digital agenda are, also, addressed through the integration and development of a network of sensors for the acquisition of the necessary information for the digital twin of laser welding processes operation.</p> <p>As foreseen by the National Research Plan (PNR), the proposed training program is innovative and aims at the multidisciplinary human capital. The program is able to attract foreign researchers and support young people in the competition to make production processes innovative, highly efficient and sustainable through numerical/mathematical models that can be implemented on industrial IT platforms. The information obtained directly from the machines installed sensors and from the products characterization obtained by laser welding will be processed to encourage innovation and the interchange between research and production world, with a view to obtaining additional funding for the creation of young researchers' team pursuant to art. 24, paragraph 3, of Law 240/2010.</p>
c. Research activity proposal, methods and contents	<p>Activity 1.1 The first phase of the study will concern the bibliographic investigation, with the aim of verifying the orientation of international scientific research in this area, as well as highlighting some aspects relating to the most widely studied joining technologies. The following will be considered: the joining of dissimilar materials and the laser welding techniques towards which research has been oriented over the years; the countries where this research has been most developed, trying to understand the reasons. Furthermore, the role of</p>

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numerical simulation in the context of these processes will be highlighted.

Activity 1.2 machines set-up, materials and methods. Based on the state of the art of bibliographic research, the most appropriate materials, the best configuration and experimentation methods will be chosen.

Activity 1.3 Definition and planning of process parameters. Through Design of Experiment (DOE) techniques, the various experimental campaigns will be prepared. In this activity, predictive Finite Element (FEM) models will also be studied and developed, to have a complete picture of the influence of single sources and combined sources on the evolution of welds, in terms of thermal evolution, thermal cycles, microstructural evolution, stress, residual stresses, thermal deformations.

Activity 1.4 Test execution. In this activity, the previously planned welding tests will be performed. Ad hoc tests will also be carried out to calibrate the previously developed FE models.

Activity 1.5 Destructive and non-destructive tests for joints analysis. In this activity, mechanical (tensile, fatigue, etc.) and technological (hardness, micro-hardness, etc.) tests will be carried out to test the joints, giving particular emphasis to microstructural analysis.

Activity 1.6 Analysis of the results. The obtained results will be analyzed using statistical and artificial intelligence techniques, to correlate the process parameters with the joint characteristics and with the possible presence of defects. The previously developed FEM models will be calibrated through appropriately prepared experiments.

Activity 1.7 Process Optimization. The analyzes carried out, using statistical techniques (such as Pareto diagrams, analysis of variance (ANOVA), Response Surface Methodology (RSM), etc.) and FE model results, will be used for the process optimization.

Activity 1.8 Development of numerical models for the process planning and virtual twin laser manufacturing design by identifying the quantities to be measured and the related sensor equipment.

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a. Research activity to carry out with the company	Activities 1.4 and 1.5 will be carried out in sharing with the firm.
b. Period of company-based study and research	6 months
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>The results verification and measurement process will take place through the following actions:</p> <ul style="list-style-type: none"> - access to the database of the final "open access" works produced and presented at workshops and conferences or published in magazines or on the department's website. On the website will provide all the information about the project, the single units and the held and to be carried out meetings. The accesses and contacts monitoring will give information on the goodness of the undertaken activities. - Meetings and workshops numbers, national and international conferences presentations at which the results of the doctoral project will be publicly described. On such occasion, it will be possible to verify the ongoing actions carried out consistency in relation to the objectives and, obviously, the collection of useful feedback for their further development and improvement - verify the issues attractiveness to the reference scientific and institutional community, thanks to the obtained results publication in journals indexed in the most important Scopus and Web of Science databases. <p>Furthermore, to guarantee the indications of REACT-EU, the involvement of institutions authoritative representatives, institution (Districts and Clusters) and, directly or indirectly, interested aggregations and associations, will be encouraged.</p> <p>The Puglia Region Aerospace and Mechatronics districts involvement, will be able to guarantee the extent of the response of companies in the sector to the topics proposed in this PhD project.</p>
C. ACTIVITIES ABROAD	
a. Research activity abroad	Activities 1.6, 1.7, 1.8 could be carried out in sharing with a foreign university.

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INNOVATION-BASED TOPICS (ACTION IV.4)

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A. RESEARCH PROPOSAL

Numerical and experimental methods for innovative design in Truck & Trails field

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and the formation of professional profiles as a response to the requirements of the business sector for innovation and competitiveness.

A development of research on topics of innovation, digital advancement and enabling technology while supporting the enhancement of human capital, determining factors in the progress of research and innovation in Italy.

The automotive and truck & trailers is one of the main sectors of the Italian industry. in accordance with the data reported by ANFIA (National Association of Automobile Industry Sector) in 2019 the sector employed about 275,000 employees in over 5500 companies with a global turnover of 106 billion euros. In fact, the sector includes thousands of medium and small companies (SME) that produce components. One of the greatest limits to the technological development of the entire vehicle production chain are related with this small companies that sometimes do not have the necessary resources to follow the technological development. Therefore, it is necessary to provide to these SMEs new technological tools for innovative design that allow them to create products up to date.

Indeed, the automotive sector, including truck & trailers, is in the middle of a technological revolution due to the request to reduce the environmental impact and the CO₂ emissions.

To achieve these goals, weight reduction is essential. This can only be obtained with smart design. For those reasons, it is necessary to train new figures that will be able to use and develop innovative design methods that combine analytical-numerical techniques with

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	<p>experimental analyzes, as well as a better ability to analyze materials.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students, with the aim of fostering innovation and exchange between the field of research and world of manufacturing and the certification of research project contributions within the sector of innovation (Law 240/2010, art. 24, section 3 and subsequent modifications and additions).</p>	<p>The development of new design methodologies that integrate innovative experimental technologies for the analysis of the stresses and the behavior of materials as well as the implementation of innovative numerical-analytical models, fits perfectly into the technological platform "Smart and sustainable energy and environment industry", outlined by National Strategy of Intelligent Specialization, as it aims to implement evolutionary and adaptive production systems as well as the use of innovative and environmentally friendly materials.</p> <p>In fact, the growth of production systems cannot be separated from the use of better design techniques, as a more accurate analysis and knowledge of materials behavior (e.g. experimental analysis and modeling of materials), as well as the conditions of use of the product (e.g. analysis of the real load conditions), up to the analysis of the end of the life cycle of the product to optimize the recycling of the various parts.</p> <p>As part of this doctoral course, innovative stress analysis processes will be developed (e.g. distributed sensors, optical non-contact methodologies, etc.) as well as analysis and modeling of the behavior of materials that take into account also the effects of the parameters of processes and the aging phenomena of the materials.</p> <p>The work will focus on plastic materials that happens to be of great interest to the partner company.</p> <p>The course will also act as a driving force for the exchange of ideas and activities between the university and the industry and it will develop during the entire time span of the doctorate.</p>
<p>c. Research activity proposal, methods and contents</p>	<p>The main goal of the research proposal is to provide innovative experimental, analytical and IT tools to analyze the behavior of materials and components.</p> <p>In fact, in the last decade, the development of a new industrial framework based on data exchanges, modern automation systems and innovations in design and production (Industry 4.0) have led to heavy transformations in manufacturing processes allowing the diffusion of innovative technologies. The project will integrate the numerical / analytical modelling (e.g. implementation of constitutive models; optimization of the structures) and the experimental analysis (e.g. implementation of innovative experimental tests for the mechanical characterization of materials and structures).</p> <p>The first goal of the research is to develop advanced constitutive models to analyze the behavior of plastic</p>

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	<p>materials. These will also have to take into account the effects of production parameters as well as aging of the materials on the characteristics of the final product.</p> <p>The second objective of the research project is to identify specific and innovative characterization techniques (e.g. full-field optical methodologies).</p> <p>Finally, the third objective of the research project is to develop design methodologies and practices that take into account the characteristics of these materials as well as the possibility of developing innovative experimental procedure to analyze the real behavior of the components during use.</p>
<p>B. COMPANY-BASED ACTIVITIES within the Italian territory</p>	
<p>a. Research activity to carry out with the company</p>	<p>The collaboration aims to create an experimentation and measurement department that can interact with simulations department concerning, in particular, the structural functions of the Ansys software. The ultimate purposes are to study the correlations between physical reality and virtual reality, to identify new methods and procedures to test and measure products responses under real loads, to innovate the use of materials for lightening structures, with a consequent reduction of the consumptions and of the CO₂ emissions of heavy vehicles.</p>
<p>b. Period of company-based study and research</p>	<p>6 months</p>
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>The PhD program is expected to publish of at least 3 papers on international journals, to participate at 2 international conferences and to file 1 patent in collaboration with the company partner. The research results will be also promoted into workshops and seminars dedicated to stakeholders in the automotive sector.</p> <p>Furthermore, the awaited impact on the partner company will be the growth of the research and development department 1 year after the end of the doctorate due to expansion of the internal structures including the increase of the staff dedicated to R&D, as well as the creation, 1 year after the end of the PhD, of new production lines dedicated to products developed with innovative design techniques, with consequent direct and indirect effects on employment levels.</p>

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UNIONE EUROPEA
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National Operational Programme 2014-2020 PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

SCHOLARSHIP N. 21

A. RESEARCH PROPOSAL

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as;

- protection of the ecosystem;
- biodiversity;
- reduction of climate change impact;
- enhancement of sustainable development

in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.

The main objective of this PhD program proposal is the development and the implementation of lubricants characterized by very high efficiency but *low/negligible environmental impact*. Lubricating and cooling fluids are largely used and they often play a key role in production processes because they are able not only to limit power absorption but also to safeguard both the materials being processed and the machinery by limiting their out of service. Thus the proposed topic actually plays a central role in the manufacturing industry since it is essential because environmental sustainability has become a real commitment and it represents the reflection of a renewed mentality and attention of management, without looking at mere legal obligations.

In this research, the focus shall be on coolant fluids used both in machining and metal forming processes, being the aim to greatly simplify the disposal of the exhausted emulsions. In both applications, the friction reduction ensured by

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	<p>the lubricants leads to a lower energy consumption along with a reduced costs of equipment/machinery if compared to alternative dry solutions (for example by coating the tool's surface) or to the adoption of machines able to withstand higher temperature levels. The development of cooling lubricants characterized by optimal performance (in terms not only of lubrication capacity, but also of corrosion protection) can also allow to combine the reduction of costs linked to the very low environmental impact with the increase in productivity determined by the reduction of downtime for maintenance (not only breakage, but also worn tool's replacement). A production cycle in which this type of cooling lubricants is optimally implemented can significantly allow sustainable development, that is worthy to be investigated aiming at overcoming the effects of the crisis over the last 2 years.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.</p>	<p>Nowadays, many companies have decided to drive their production route towards sustainable development, committing themselves to reducing the environmental impact of production activities with the consequent modification of products and processes. If we consider the entire production chain, innovation becomes the key to obtain indisputable advantages. The transformation towards the green manufacturing is not only proving to be a communicative strength affecting the reputation of a brand, increasing its visibility and the end-users, but it represents also path toward the reduction of costs and risks and more advanced business models.</p> <p>According with the National Strategy of Intelligent Specialization (SNSI), which has identified the long-term investment priorities, declining them into 5 thematic areas of strategic interest, the proposed PhD program belongs to the area titled "<i>Intelligent and sustainable industry, energy and environment</i>". The goal of the project is, in fact, the development and implementation within the production cycle of efficient and green cooling lubricants (i.e., with</p>

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	<p>very low environmental impact) to replace mineral-based fluids.</p> <p>The present PhD program also perfectly matches the <i>National Research Program</i> (PNR) according to which “Green technologies” represent one of the areas of intervention that fall within the scope of research and innovation "<i>Food products, bioeconomy, natural resources, agriculture, environment</i>". The PNR, in fact, pushes on the development of a sustainable and circular industrial economy by considering the concepts of "regenerative chemistry" (which aims at the requalification and recovery of secondary raw materials from end-of-life products) and "<i>de-manufacturing and re-manufacturing</i> " (increase the life time of products with high added value, recovery of critical resources, use in secondary processes, etc.) as strategic.</p> <p>The circular economy is closely linked to the topic of sustainability since a component at the end of its work can be broken down and reintroduced, as far as possible, into a new production cycle, generating an additional value. Today we are facing an increase in demand for raw materials that collides with shortage of supply. The circular economy can compensate such a lack by providing manufacturing costly-effective solutions that involve the reuse of materials (in this case exhausted oils) and products to extend their life cycle, also contributing to the waste reduction.</p>
c. Research activity proposal, methods and contents	<p>This research proposal shall be focused on the study of eco-friendly (<i>green</i>) cooling lubricants. It should be noted that, in order to have an implementation within the production cycle, it is necessary to identify the operating conditions to maximize the performance of the specific fluid and define the optimal percentage composition of its emulsion.</p> <p>An initial phase based on the investigation of currently-used fluids (mineral-based formulations) will be followed by the</p>

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	<p>development of cooling lubricants able to ensure optimal performance and, at the same time, really straightforward disposal procedures. A numerical/experimental approach shall be used based on both laboratory tests and by involving production companies in Italy and abroad interested in the development of <i>green</i> products; in addition, numerical simulations shall be conducted in order to define the operating conditions to be investigated in experiments in the manufacturing processes. In fact, laboratory tests will also provide experimental data useful for the calibration of the simulation models to be used for the definition of the process working window. In this way, the experimental phase can be better focused and will simplify the definitive implementation of the environmental-friendly fluids within the manufacturing process.</p>
<p>B. COMPANY-BASED ACTIVITIES within the Italian territory</p>	
<p>a. Research activity to carry out with the company</p>	<p>The research activity will be carried out at a company which operates in the field of chemistry and which it is able to integrate green chemistry with plant engineering. The company shall be involved in the formulation of oils for the steel industry with particular attention to metal cutting and rolling applications. The research activities shall be of two types:</p> <ol style="list-style-type: none"> 1. Laboratory tests carried out at the company, which will be used for creating (validating) the numerical models able to simulate the industrial process; 2. Trials at industrial plants, aimed at the implementation of green cooling lubricant fluids within their manufacturing processes (metal cutting and bulk forming processes).
<p>b. Period of company-based study and research</p>	<p>12 months</p>
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to</p>	<p>This project is part of the idea of <i>transition to a green economy</i> financed by the FESR within REACT-EU, which is one of the largest</p>

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<p>the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>programmes under the new Next Generation EU instrument. The planned research activity shall be divided into different phases to be conducted at PoliBa or at the company. For each phase expected results and the way to check them have to be detailed, describing in particular:</p> <ul style="list-style-type: none">- the main characteristics of the cooling lubricants- the need of specific equipment- the type of green fluids to be investigated- the type of tests and instruments to be used- the type and the methodology of industrial tests- the numerical approach to be used
<p>C. ACTIVITIES ABROAD</p>	
<p>a. Research activity abroad</p>	<p>This PhD program therefore also implies that part of the activities will be carried out abroad in company interested in the implementation of the formulated <i>green</i> cooling lubricants. The international market (South Africa, Iran, Turkey) is in fact moving very rapidly toward the use of highly efficient but low environmental impact rolling oils.</p>

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National Operational Programme 2014-2020 PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

SCHOLARSHIP N. 22

A. RESEARCH PROPOSAL

Development of turbines in substitution of regulating valves for the recovery and production of energy otherwise wasted

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as;

- protection of the ecosystem;
- biodiversity;
- reduction of climate change impact;
- enhancement of sustainable development

in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.

The project proposes alternative solutions for the recovery and production of energy, otherwise wasted within the conventional systems of regulation and control of flow rates and pressures in industrial processes. This will support the growth of increasingly sustainable industries from an energy point of view by reducing the carbon footprint of their processes. The topics covered will strengthen the position of the Apulia Region as a national and international player in the clean energy sector.

The project fits well within the agreements stipulated between the Apulia Region, the Polytechnic University of Bari and the most important regional industrial companies to develop themes relating to the green energy. It is worth citing the recent agreement between Baker Hughes and the Polytechnic University of Bari, which established the public-private laboratory "Baker Hughes Pump Lab", which also has among its aims research in the field of energy recovery machines. The project fits in a

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	<p>framework characterized by a collaboration of many years with the Italian partner which operates in the field of centrifugal pumps. The company, due to market needs and product diversification, has shown a strong interest in developing centrifugal pumps to be used in reverse mode for energy recovery, the so-called PaT (Pump as Turbine).</p> <p>Furthermore, the project will allow the Polytechnic University of Bari to strengthen collaborations with important European research centers, including the foreign partner. Finally, the acquired know-how will allow for the creation of new partnerships in transversal sectors with respect to the energy one, ranging from the field of mechanical and civil engineering to the electrical and management sector.</p> <p>The achievement of the objectives will make it possible to integrate PaTs in the context of industry 4.0 and the Internet of Things, through network connection and monitoring of operating conditions. This smart regulation will allow interconnection between PaTs and the production processes already equipped with smart control and storage systems, to maximize the power that can be recovered from these processes.</p> <p>The experience gained during the PhD period will ensure that this figure, capable of bringing innovation in the field of sustainable energy production, can be easily inserted within the company or in other industrial groups operating in the turbomachinery sector, as happened in the past with the PhDs who carried out their own projects on issues of corporate interest in the energy sector.</p>
<p>b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.</p>	<p>The need to fight against climate change and respond with green solutions to the growing global energy demand is leading to an increase in investments in industrial processes, aimed at maximizing the recovery of energy flows that would otherwise be dissipated.</p> <p>Under this framework, this research proposal will focus on the development of new centrifugal pumps to be used in reverse mode with adjustable inlet guide vanes, the so-called Pump as Turbines, for energy recovery. Among</p>

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the main applications involved in this development there are gas treatment plants, petrochemical plants, oil pipelines, as well as water distribution networks.

In the past, flow control was ensured by lamination systems (valves) which necessarily dissipated energy. The same function is now often performed by turbines which allow to partially convert the energy previously dissipated in the valve into usable mechanical energy. However, in many cases there is a strong variability of the flow rate to be treated with a consequent request for operational flexibility of the machine installed for energy recovery.

The use of adjustable blades at the inlet of turbines is a very effective and already consolidated technology in the field of hydroelectric plants, whereas it has never been applied in other industrial areas where the turbine outlet is at high pressure. The design of these components is therefore highly innovative, especially if the aim is to create at the same time economical and reliable drive mechanisms.

Another field of application of these machines is in the turbo-groups used in petrochemical plants, such as those for the production of fertilizers. Usually the turbo-groups available on the market are of small size and power (<300 kW) and do not have systems to extend the operating range of flow other than a simple bypass valve. The extension to higher powers (at least up to 500kW) and the extension of the operating range of the flow rates with the use of adjustable inlet guide vanes aims to increase the average annual energy recovery but above all shorten the payback period.

In this scenario, energy management by means of storage systems capable of making the production and distribution of energy in the processes of interest more sustainable will be important.

The project is therefore well fitted in the green field, thanks to the reduction of the impacts of climate change and the promotion of a smart and sustainable management of low CO₂ content energy, catalysts for the large area of intervention of the green transition identified by the PNR, and present in the thematic area of

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	<p>the SNSI aimed at making the industry more sustainable in a clean energy and environmental context.</p>
<p>c. Research activity proposal, methods and contents</p>	<p>The research activity will take advantage of the close synergy with the partner.</p> <p>Traditionally, the Bari site has mainly developed centrifugal pump. Market demands and the need to diversify production to maintain competitiveness have led the group to develop special centrifugal pumps to be used in reverse mode, the so-called PaT (Pump as Turbine).</p> <p>Centrifugal pumps, eventually equipped with vaned diffuser, basically have fixed diffuser vanes. When the pump has to work as a turbine, the diffuser assumes the role of distributor. However, in order to have a wide operating range with high efficiency, it is necessary to have variable inlet guide vanes; hence, the entire pump diffuser needs to be re-designed.</p> <p>Another important issue is that, unlike centrifugal pumps, the stresses on the impeller blades of pumps operating in reverse mode in the presence of static guide vanes can contain stresses at very high frequencies. For an optimal design, i.e. minimum cost in compliance with structural constraints, it is necessary to be able to accurately predict the extent of these flow-induced stresses.</p> <p>Therefore, the proposed research activity involves a campaign of numerical simulations on different types of configurations with the aim at identifying the most influential geometric and fluid-dynamic parameters on the improvement of turbine performance. Furthermore, the numerical results will be fundamental in order to validate the design process.</p> <p>Following these numerical activities, experimental tests will be carried out to characterize the machine in different operating conditions. In order to obtain a prompt response of the systems to the conditions variations, evolutionary learning algorithms for analysis, performance prediction and diagnostics will be developed. In this way PaTs will be integrated in the context of industry 4.0 and the Internet of Things to maximize recoverable power from processes and optimize its management</p>

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	<p>through interconnected storage systems. This will be made possible thanks to the experimental facilities of the partner and the Department of Mechanics, Mathematics and Management of the Polytechnic University of Bari for the experimental characterization of hydraulic pumps and turbines.</p> <p>Finally, the field relating to the application of these machines to processes where a considerable part of gas dissolved in the liquid comes out of the solution during expansion is also unexplored.</p>
<p>B. COMPANY-BASED ACTIVITIES within the Italian territory</p>	
<p>a. Research activity to carry out with the company</p>	<p>The partner has continuously invested in the innovation of its products and in the introduction of new ones, from large gas turbines to valves for their control, since its foundation 150 years ago. The main activity of the plant is the design and production of large single or multi-stage centrifugal pumps for industrial plants and oil pipelines.</p> <p>The activities to be carried out at the partner plant are related to the more applicative aspects of the research project. Specifically, the activities are:</p> <ul style="list-style-type: none"> • Conceptual definition and modeling of the general machine architecture; • Detailed definition and modeling of the components of the flow path and of the actuation parts; • Preparation and fine-tuning of the experimental validation phase.
<p>b. Period of company-based study and research</p>	<p>12 months</p>
<p>c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.</p>	<p>For the partner, the development of this new technology could open up new shares of the market, increasing the group's potential. The increase in scope generated by this project will require the assignment of new highly qualified personnel. The experience accumulated during the PhD period will ensure that this figure can be easily inserted within the company.</p> <p>Thanks to the long-term collaboration between the company and the Polytechnic University of Bari it is believed to be able to achieve the</p>

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	<p>objectives in the three years of the duration of the PhD Course.</p> <p>This is confirmed by the development of an innovative impeller of a double-flow centrifugal pump that was entirely conceived and designed from scratch by a joint work group. The excellent experimental results on the first prototype made led to the filing of a patent application which was accepted.</p> <p>The reference mechanical and hydraulic configurations, useful to start for the development of this project proposal are centrifugal pumps for petrochemical industrial applications, Francis-type hydraulic turbines and gas turbo-expanders. These three types of reference machines are part of the product portfolio of the project partner company.</p> <p>The three-year project will be divided into semesters.</p> <ol style="list-style-type: none">1) 1st and 2nd semester, at Polytechnic University of Bari: the PhD student will study the problem by carrying out a detailed state-of-the-art analysis. Furthermore, the first numerical models will be created for the evaluation of the fluid dynamic behavior of the system and for the identification of the main operating conditions. In the meantime, he will dedicate himself to obtaining the necessary university credits relating to the training part;2) 3rd semester, at the company: in this phase, in collaboration with the company staff, the machine will be preliminary developed;3) 4th semester, at the EPFL: theoretical and experimental analysis of the rotor-stator interaction;4) 5th semester, at the company: execution of the final design of the system and experimental tests;5) 6th semester, at the Polytechnic University of Bari, numerical simulations for verification and drafting of the thesis work.
C. ACTIVITIES ABROAD	
a. Research activity abroad	The foreign partner is one of the most prestigious international institutes in the study of hydraulic turbomachinery. During the period abroad there will be an involvement in the research group and in the main experimental

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	<p>activities carried out at the laboratory for hydraulic machines.</p> <p>The PhD student will participate in experimental tests on small-scale turbines to perform measurements of efficiency, pressure oscillations and speed fields at the output of the impeller to study the biphasic and rotor-stator interaction phenomena that can damage the performance and safety of the hydraulic machine.</p>
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