DOTTORATO DI RICERCA INTERATENEO CON L'UNIVERSITÀ DEGLI STUDI DI BARI

IN

SMART AND SUSTAINABLE INDUSTRY

XLI CICLO

Project Outline:

Polytechnic University of Bari and University of Bari 'Aldo Moro' propose the Interateneo Doctoral Course in Smart and Sustainable Industry.

The Course pursues training and research in the field of interdisciplinary enabling technologies for Smart and Sustainable Industry as defined by the European Union and identified in the National Research Plan, in the Enterprise National Plan 4.0 and confirmed in the Transition Plan 4.0, as well as in the National Recovery and Resilience Plan, through the integration and cross-fertilization of basic sciences (ERC sectors PE1-PE5), computer and information sciences (ERC sector PE6) with Information Engineering (ERC sector PE7) and Industrial Engineering (ERC sector PE8). Therefore, the training project involves contributions from CUN scientific-disciplinary areas 01 (Mathematical and Computer Sciences), 02 (Physical Sciences), 03 (Chemical Sciences) and 09 (Industrial and Information Engineering).

The interdisciplinarity of the proposed doctoral program is attested by the number of scientific-disciplinary fields represented in the Ph.D. Board and belonging to the Departments of Electrical and Information Engineering (DEI-PoliBA), Mechanics, Mathematics and Management (DMMM-PoliBA), of Architecture, Construction and Design (ARCOD-PoliBA), Inter-University Department of Physics (DIF-PoliBA/UniBA), Department of Chemistry (UniBA), Department of Computer Science (UniBA) and Department of Engineering (LUM), as well as in those of the foreign institutions involved and in the Institutes of the National Research Council. An important contribution to the achievement of the educational goals of the Doctoral Program is provided by the Enterprises with their representatives in the Ph.D. Board, which will be able to strengthen the relationship between academic research and institutions, the territory and industry to better meet the challenges of innovation.

Member of the Ph.D. Board are involved in research projects relevant to the local and national business community and have numerous scientific collaborations in international contexts.

Research and development related to the Smart and Sustainable Industry encompasses a significant number of macro-areas including enabling technologies, such as augmented and virtual reality, collaborative and programmable robotics, intelligent automation, nanotechnology, smart materials, sensors and control techniques, machine learning and artificial intelligence, which can support the transformation towards a more digitized and sustainable industry; strategies for digital conversion; smart products and services, materials and production processes; smart factories, working methods and production systems.

Through a customized training plan, at the conclusion of the doctoral program, PhDs will have acquired a multi- and inter-disciplinary background and critical skills enabling them to operate on highly complex and knowledge-intensive systems in multiple market contexts, to conduct innovative research, carry out technology transfer, develop applications, and contribute to rapid innovation of processes, products and services.

Course goals:

The Ph.D. Program in Smart and Sustainable Industry aims to train experts with a high scientific profile, capable of contributing to technological innovation, digital transformation and sustainable development of the major production chains in the national and international landscape, providing students with a solid foundation for understanding fundamental physicochemical phenomena and the most complex and challenging engineering problems, as well as a thorough knowledge of the numerical and experimental methodologies and approaches necessary for their analysis and implementation.

The Course makes use of a relevant network of research interactions in the different application areas and of the strong synergies between the involved areas of the Polytechnic University of Bari and the University of Bari 'Aldo Moro', capitalizing on the expertise gained in the very numerous technology transfer programs of the proposing universities and the potential of their many public-private laboratories and of the industrial research initiatives under way in the regional and national territory.

The Course is divided into two interconnected cultural macro-environments to ensure the strongly interdisciplinary educational objectives:

- Core technologies that include embedded systems, smart sensor networks, ICT, Internet of Things, Industrial Internet, Big Data and Analytics, Fog/Cloud/Mobile Edge Computing, cybersecurity, industrial automation and measurement systems, robotics, smart machine development, mechanical design and machining technologies, process engineering, evolutionary and adaptive manufacturing systems, efficient and sustainable energy systems, and organizational process and business model innovation.
- Emerging technologies, including nanotechnology and advanced materials, additive manufacturing, rapid prototyping, industrial tribology, advanced devices and sensors, smart systems, quantum technology, smart wearable devices, collaborative robotics, advanced Human Machine Interface, cognitive automation, advanced machine learning, virtual & augmented reality, metaverse, digital twin and simulation, human-centered artificial intelligence, blockchain, smart education and training for technology transfer.

Technologies will be explored with a sensitivity aimed at social, economic and environmental sustainability and the improvement of human well-being.

To train Ph.D.s capable of contributing to technological innovation, digital transformation and sustainable development of the major production chains in the national and international panorama, the Ph.D. Board identifies for each student a personalized training path that allows an adequate degree of in-depth study in line with specific interests and talents. The path

includes, together with the specifically defined research activity for an overall commitment of 120 ECTS, also a didactic activity for a maximum number of 60 ECTS, in accordance with the didactic regulations of the Doctoral School (SCUDO) of the Polytechnic University of Bari (https://www.poliba.it/sites/default/files/dottorati/regscudo2021.pdf), to be carried out preferably in the first two years.

The teaching activity carried out, typically, in the first year is geared toward making the core competencies more homogeneous. Students can then follow specialized teachings activated to achieve the specific objectives of the Course. Doctoral didactics includes teachings offered by SCUDO (https://www.poliba.it/it/dottorato-di-ricerca-pagina/offerta-didattica) from which the student can choose the most suitable ones to enrich his or her training in agreement with the Supervisor and the Ph.D. Board.

The SCUDO's educational offerings are divided into three levels: level 1-choice basket of subjects of common interest; level 2-choice baskets of interest for specific subject areas; level 3-choice baskets at the proposal of the Doctoral Colleges (details on the teachings proposed by the SSI Board in relation to levels 2 and 3 are given in Section 4).

The doctoral teaching of the Doctoral Program is complemented by seminar tracks (http://phd-ssi.poliba.it/scientific-events/), focusing on specific aspects related to technological innovation, digital transformation and sustainable development of industry, also organized in collaboration with large companies, SMEs and research centers, with which there are already numerous and well-established collaborative relationships.

Students are strongly advised to study at foreign Universities or Research Centers of relevant international prestige, as well as to interact closely with the industrial world, which is also functional for a better understanding of technology transfer processes and implicit for educational paths with a stronger characterization in this direction.

Expected employment and professional outlets:

The ALMALAUREA 2023 report on the profile and employment condition of Ph.D.s attests the high effectiveness of the skills acquired during the doctoral course for the performance of the specific work activity, witnessed by about 77% of those employed, as well as the high rate of employment (about equal to 91%) already one year after obtaining the Ph.D. degree, with an average of only three months to find the first job opportunity with a high degree of specialization.

The employment status of Ph.D.s is, therefore, better than that of graduates in the same CUN areas pertaining to the Ph.D. program, with about 84 percent of those employed in an “intellectual, scientific and highly specialized profession”.

In addition, at this historical stage, companies are being called upon to invest in digital technologies useful to support the transition to Intelligent Industry and Sustainable Development and, as a result, need to find qualified personnel functional for this purpose. The Excelsior report by Unioncamere-ANPAL 2023 forecasts a total need for about 4 million workers in the period 2023-2027, with a clear growth in the demand for technical figures, especially in areas such as digital, green and demographic that will have an increasingly significant impact

on the labor market, in the coming years. A comparison of supply and demand shows an insufficient supply to cover the needs of the economic system, with significant differences between different fields of study. For STEM areas, the most critical mismatches are found in the mathematical, physical and computer sciences and engineering fields. Thus, there remains a critical situation in the skills of individuals that do not fully match the needs for technological innovation and digital and sustainable transformation of industry.

The specific skills acquired at the end of the doctoral program in Smart and Sustainable Industry fully meet the needs of key professional figures in the development of systems with high technological content, expressed by the modern manufacturing industry that is called to constantly invest in process, product and service innovation.

Among the industrial sectors of outlet, and of particular interest in the regional and national context, it seems relevant to mention: aerospace, automotive, mobility and transport, smart city, biomedicine, mechanics and mechatronics, agribusiness, electronics, information technology, telecommunications, energy, logistics, steel, textile-clothing-footwear, and manufacturing. In addition to these sectors, professional outlets can be identified for trained PhDs in research and development activities for the service industry, as well as for systems, products and services related to resource management.

PhDs in Smart and Sustainable Industry will be able to work as professional consultants also required by industrial realities for the management of innovation processes and as experts for the development of European Union research programs.

Finally, some of the trained Ph.D.s may take academic roles at Italian and foreign universities as well as become researchers at public and private research organizations, and at consortia for sustainable development and technological innovation in industry.