



PhD in DESIGN - 39th cycle

PNRR 117 Research Field: E-TEXTILES ECO-DESIGN STRATEGIES TOWARD CIRCULARITY AND SUSTAINABILITY

Monthly net income of PhDscholarship (max 36 months)

€ 1195.5

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

The market of e-textiles is experiencing unprecedented growth, surmounting \$780 million by the year 2033 (Dyson, 2023), because of the increasing interest in applicative sectors such as health, sports, professional protection, and entertainment. Of these sectors, E-textiles designed for sports have gained significant attention because they could support the professional and amatorial activities of athletes to track vital metrics, optimize training routines, and prevent injuries. Besides, E-textiles in sportswear are more likely to gain acceptance in the mass market, as demonstrated by the rate of growth of the wearable fitness market to US\$34 billion in 2020 (Meena et al., 2023). Facing this increasing commercial interest, it is crucial to address the challenges of sustainable manufacturing by considering their product circularity and End of Life (EoL) management at the design stage. An emphasis of the research on e-textile disposal, disassembly, and recyclability is necessary due to the differing obsolescence of textiles and electronic components, the evolving trends for textiles' styles and aesthetics, the quick update of the performance of electronic products, and the current practice of incineration of e-textile at the end of their life. Currently, there is a lack of knowledge and experience in this field (Dulal et al., 2022). E-textile recycling classifications have not yet been established in the actual textile recycling legislation (Xie et al., 2021), and existing e-waste recycling financing schemes do not cover this new type of waste. Besides, currently, no labeling standards are available for taking care e- textiles (Smart Textile



	Alliance, 2021). Recognizing the importance of design choices in e-textile development and manufacturing, this Ph.D. research proposal aims to explore different eco-design strategies and recycling approaches of e-textiles that will support their EoL impacts toward sustainability and circularity. The proposition of acting at the level of design to prevent waste is based on the implementation of Design for Recyclability of Materials (DfR), Design for Modularity (DfM) through modular construction for easy removal and replacement of the obsolescent parts, and Design for Disassembly (DfD).
Methods and techniques that will be developed and used to carry out the research	Given the actuality, the importance of acting proactively and promptly to face the rapid evolution of the market in order to guarantee e-textiles' innovation, production, technological feasibility, market scalability along with sustainability embracing the four dimensions of environment, economy, society, and culture, this Ph.D. proposal is proposing an interdisciplinary and cross-sectoral approach, focusing on the collaboration between stakeholders including textile suppliers, sportive garment brands, fashion designers, engineers and bio-engineers, manufacturers, recyclers, and policymakers to tackle the challenges and promote sustainable practices in the design and manufacturing phases that will contribute to circularity actions at the EoL stages of e-textiles. A synergistic collaborative research between the world of production of sportive smart garments, the research center dedicated to sustainability and circularity in the textile field, and a university focused on a design-led systemic approach (or systemic design) would encourage a paradigmatic change, raising awareness, and integrate recycling considerations into the early stages of E-textile design and development. Therefore, an initial comprehensive literature review will delve into the state of the art of academic studies, and actual legislation about the current eco-design strategies for ensuring e-textile sustainability and circularity with the aim of the elaboration of a holistic representation of the system in which the research intervenes (context-based design). An integration analyzing relevant case studies will access the state of the art of companies working in the design and



	manufacturing of sustainable and circular E-textile in the sportive performance sector. The scope is producing possible alternative scenarios to anticipate the effect of possible interdependencies between e-textiles' advanced multiple functionalities, comfort, and sustainability/circularity in relation to design, manufacturing, distribution, use, and EoL processes. Scenarios could be validated and used as a prompt of discussion between the different actors and teams of researchers involved in the Ph.D. research in order to achieve better collaboration, by improving interdisciplinary co-design processes. A series of research-through-design experimental projects will be launched to pilot and test the winning strategies in real contexts and provide validation to design approaches to achieve circularity and sustainability.
Educational objectives	The joint research and experimentation activities between the company, university, and research centre conducted during the Ph.D. activities will make it possible for the candidate to: - produce evidence on the effectiveness of the approach design-led systems in generating positive impacts and contributing to the resolution of complex sustainability problems arising in the e-textile sector; - develop and test methodologies, tools, and processes for the design of sustainable products and the construction of circular economy supply chains, responding to the growing demand for support from the national and international economic system, integrating the use of new materials and components, the extension of product life cycles, maintenance and servitisation, and the prevention, reduction, and valorisation of waste. - focus on the role of design in driving a positive change in e-textile design and manufacturing through experimenting with technologies to increase the circularity and sustainability, along with comfort and performance of e-textiles applied in the sportswear sector; - develop substantial knowledge and expertise in the area of specialization of e-textiles for professional and amatorial sports performance, demonstrating the ability to make original and significant contributions to be



	disseminated at the scientific level and taught at university-level courses; - bridge the gap between research in academia and in the industries in the fashion-tech sector towards the innovative and sustainable development of e-textiles, providing toolkit and crucial insights and practices to define a collaborative model of co-creativity between involved stakeholders; - collaborate with interdisciplinary researchers from the domain of engineering and computer science, which could contribute to the enhancement of the soft skills of the candidate, demonstrating the ability to work effectively with other people from various educational, and work experience backgrounds; - extend subject-specific skills in the area of e-textiles with a logic of cross-fertilization, synergistic growth, collaboration, and mutual co-design between the industries; - extend subject-specific skills in the area of e-textiles in the sportswear sector with a logic of synergistic collaboration, and co-design between the tech industries and fashion industries, along with the stakeholders involved in the recycling processes; - master the analytical and methodological skills required to evaluate and conduct research in this area of specialization and related areas. - legitimise the systemic approach specific to design among policymakers, researchers from other disciplinary areas, and the fashion-tech industries as an effective strategy to positively drive the transformation in contemporary social, economic, and technological systems toward sustainability and circularity
Job opportunities	The fashion-tech and e-textile industries are witnessing a remarkable surge in job opportunities, driven by the increasing demand for sustainable and technologically advanced solutions. Today, these sectors are generating a substantial number of new jobs, and future projections indicate even more growth. McKinsey (2022) reports that this figure will double to 3% to 3.5% by 2030 as the fashion-tech industry continues to grow at a faster rate than ever before. According to Teunissen and Danjoux



	(2021), transformative changes in fashion professionals are necessary to shape its future directions. The report underscores the emergence of new job roles and skills related to the sustainable fashion-tech designer, equipped with creativity skills with a profound understanding of eco-friendly materials and manufacturing processes, aiming to create garments that minimize environmental impact while fulfilling aesthetic and functional requirements. As sustainability is becoming a priority for fashion brands, these professionals assess and advise on the environmental and social impact of their operations, conducting life-cycle assessments, analysing supply chains, and recommending strategies for reducing waste, carbon emissions, and water consumption. Besides, a growing interest is in hybrid figures that possess subject-specific knowledge as fashion technologists or e-textile engineers who specialize in integrating technology into clothing and accessories. These professionals will possess expertise in fields like smart textiles, wearable electronics, and material science, able to incorporate sensors, conductive fabrics, and interactive elements into garments, creating innovative and technologically advanced fashion products.
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 1 PhD Students
Name of the research directors	Daria Casciani

Contacts
email: daria.casciani@polimi.it https://shorturl.at/lxGW3

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

Scholarship Increase for a period abroad	
Amount monthly	597.75 €
By number of months	0



National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	H3CUBE
By number of months at the company	12
Institution or company where the candidate will spend the period abroad (name and brief description)	TU/Delft (Technische Universiteit of Delft)
By number of months abroad	6

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

Educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences):

financial aid per PhD student per year

max 4.872,90 euros per student (total for 3 years)

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD student there are various forms of financial aid both for research and teaching activities. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer availability: 1st year, 2nd year and 3rd year: Each research group will supply PhD student with a computer, if necessary.

Desk availability: 1st year, 2nd year and 3rd year: Each research group will supply phd student with a desk.