WP2: Capacity building and setting up innovation textiles' centers

Deliverable2.5:
Innovation and tech transfer plan

University of Sfax

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1. General overview of advanced textile materials

Technical textiles can be defined as all textile products that cannot be fitted within the traditional sectors of clothing or furnishing, particularly the textile products in which functionality is as much or more important than aesthetics.

The global technical textiles' market size was estimated at **USD 176.6 billion in 2019** globally, growing at a compound annual growth rate (CAGR) of 4.5% from 2020 to 2027.

Some of the factors influencing the growth of the market are:

1. Rising demand from new application areas

2. Varying consumer preferences

3. Useful physical properties of technical textiles

4. Innovation and R&D

5. Government regulations

6. Climate change and global warming

Technical textiles segment has been growing over the past decades in the total share within the textile industry, currently accounting about 27% of turnover in the overall textile sector.

1.1 Technical textiles market segmentation by type and application

The specific value chain of technical textiles, which alike the regular textilesproduction begins with natural fibers or the production of fibers by extrusion. Next, it follows (if applicable) spinning and yarn transformation to produce the fabric with yarns or directly from fibers; or the elaboration of plaited structures, webs, tapes or other types of laminar or even tridimensional textile structures that can be finished in order to give them new functional properties for specific applications.

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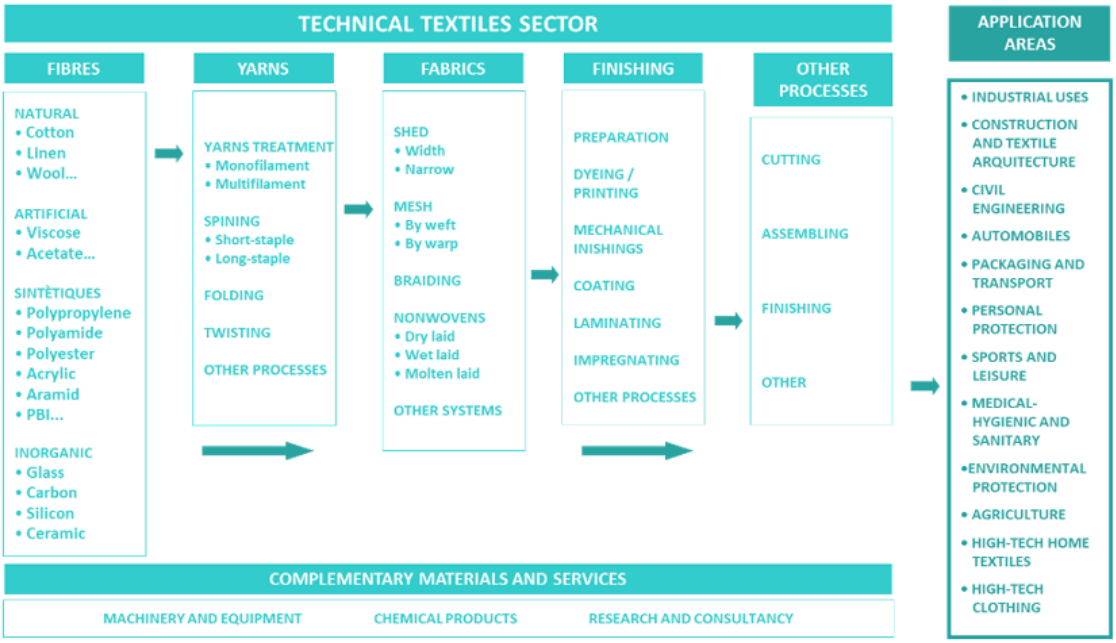
Figure (1) – Technical textiles value chain (Source: AEI Tèxtils)



The resulting products can be finished or assembled for their final use, or go through a stage of semi-finished products, such as pre-impregnated materials or adhesive materials or those used for the manufacture of composites.

Therefore, all natural, artificial, or synthetic textile fibers can be used in the field of technical textiles. However, the arrival of new fiber families with high mechanical, thermal and chemical resistance, among others, is one of the factors that has essentially contributed to the structure of the current sector of technical textiles: being able to satisfy needs that some decades ago would have never been related to textile materials.

The most usual classification of technical textiles is the one defined by the trade fair Techtextil, from Messe Frankfurt, first celebrated in 1986, and which is being used since 1997: **Agrotech**, **Buildtech**, **Clothtech**, **Geotech**, **Hometech**, **Indutech**, **Medtech**, **Mobiltech**, **Oekotech**, **Packtech**, **Protech** and **Sportech**.

Figure (2) – Application areas of technical textiles (Source: AEI Tèxtils)

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MobilTech garnered the highest market share in 2019, in terms of volume and revenue (Figure 3). This is attributed to an established consumer base in developed regions such as North America and Europe. This industry is anticipated to exhibit remarkable growth in future, majorly due to the remarkable rise in **demand for cars** with high-quality technological aspects.

Figure (3) - Technical textile markets by segment (worldwide) (Source: Allied Market Research)

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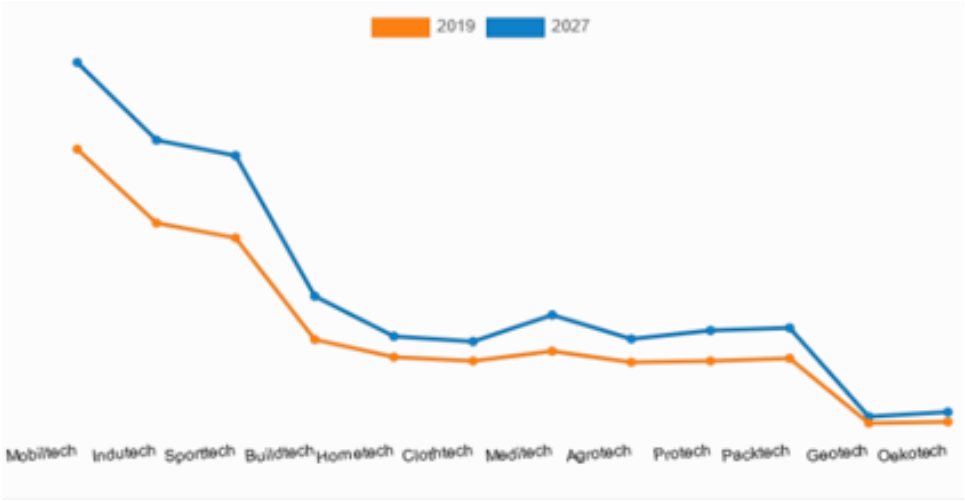

1.2 Technical textiles market and opportunities

1.2.1 Future trends

The Joint Research Center (JRC) of the European Commission, in its Industrial Landscape Vision Study 2025, estimates that by 2025, the Textile industry, including fiber-based materials, clothing, home and technical textiles, will be a strategic sector of the industry, for the European Union. *The sector is expected to offer innovative and competitive products that enable customized, adaptable and attractive solutions, integrating services for very diverse, informed and demanding consumers*. This sector will have a business model based on a globalized and efficient circular economy that maximizes the use of local resources, exploits advanced manufacturing techniques and participates in intersectoral collaborations and strategic groupings. It is estimated that the industry will implement profitable and inclusive business models and attract skilled and talented employers and workers [1].

The European Commission and the JRC have defined the main research topics and priorities until 2026, concerning the following topics as described before, in general for all TC sector:

<u>High performance and functional materials</u>

In the fibre market, innovative solutions appear thanks to the development of **bio-component fibres**, formed by two different polymers that take advantage of the qualities of both and allow get differentiated threads in their behavior.

Knowledge of the science of textile materials, coupled with the progress of industrialization, has allowed the manufacturers to obtain fibres with dazzling optical effects or hollow fibres with heat-insulating properties, etc. On the other hand, the different shape of the fibres sections promotes the evacuation of sweat perspiration to the outside of the garments.

Also, the rising ecological sensitivity of the consumers is increasingly considered, and fibre-producing companies are directing their research towards the development of **fibre that doesn't**

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harm the environment. New fibres appear, such as so-called organic fibres, which belong to the family of synthetic, artificial fibres (protein or cellulosic) or natural, such as milk protein fibres, soy protein fibres and bamboo fibres, among others.

Finally, it is worthy to mention the introduction of **graphene** as new material in the textile sector, for its properties excellent (hardness, lightness, thermal conductivity, etc.). Several research projects are currently underway focusing on the transformation of insulating tissues into fabrics with conductive properties or obtaining **electronic textiles**, among others [2].

Thus, we can sum up the main innovations in the field of materials based on the followings:

- Provide new properties and functionalities.
- New and improved polymers and additives
- Multicomponent fibers and multifilament
- New fiber surfaces
- Multifunctional textile surfaces
- New shapes/dimensions of the fibers (micro / nanofibers)
- New or improved fiber blends
- Innovative uses for conventional fibers
- Improving the sustainability of fibers (recyclable, renewable fibers/biopolymers)

Advanced manufacturing, value chains and business models

- New manufacturing technologies for the development of complex textiles and composite structures.
- Digitization and flexibility of production processes and factories.
- Virtual modeling, design of materials and products based on fibers.

Circular economy and resource efficiency

- New flexible process technologies to save water, energy, and chemicals.
- High-tech textile recycling for circular economy concepts.
- Sustainable substitutes for hazardous textile processing chemicals or biochemistry-based textile processing.
- Concepts of bio-refinery that use biomass or European waste for textile fibers.
- Greater use of natural fibers of European origin.

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1.2.2 SWOT Analysis

Table (1) - SWOT analysis of the European technical textiles' sector

STRENGTHS:	WEAKNESSES:
- Strong representation of the whole manufacturing value chain in Europe - Sophisticated information systems focused on technical and traditional textiles. - Availability of high-level infrastructures and technical centres dedicated to technical textiles. - Close relationship and cooperation with universities and research centres. - Increased product quality and improved capability to respond to highly specific consumer demands - Flexibility of the companies to adapt to the market needs - Transversal industries which allow establishing synergies with other sectors	- Lack of knowledge in new technologies - Necessary investment in new equipment - Very different skills and industry standards are needed - Lack of international experiences and skills (language). - Lack of marketing and branding skills and strategy. - The size of the companies is small, which difficult to compete in the global market - An industrial innovation culture is not generally established in textile SMEs

OPPORTUNITIES:	THREATS:
- New technologies can help to take advantage of resources and waste reduction - Academic and technological institutions of interface with the industry that allow the rapid application of new technologies	- Loss of competitive advantage for the European advanced textile materials sector. - Reduced opportunities to develop new high added value products. - High cost for the introduction of new technologies by SMEs - Loss of knowledge in the sector due to the lack of textile training offer

1.2.3 General overview of the European advanced textile market

In Europe, the technical textile market currently accounts to 24 billion €. In total production, technical textiles manufacturing is concentrated in **Italy** and **Germany**, each with about 4,5 - 5 billion € in production, followed by France with 2 billion €, Spain with about 1 billion € and Czech Republic with 800 M€.

The sector currently accounts for over **111.000 persons employed** in Europe, while the number of companies has been decreasing steadily over the past decades particularly due to the lower production costs overseas.

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In terms of trade, exports of technical textiles predominantly go to the **United States** (~2billion €) followed by China and Switzerland (both with ~1 b€). Exports of technical textiles products have doubled during the last decade, from ~500 M€ in 2010 to ~1 B€ in 2018 and show strong growth potential.

*Europe is still leader and has positive trade surplus in highly specialized products such as **medical textiles** (+758 M€ trade surplus), **nonwovens** (+555 M€ trade surplus), **coated fabrics** (+637 M€ trade surplus), and other textiles for technical use (+451 M€ trade surplus*) [3].

1.3 Key Technological Challenges

Textile technology is an *enabling technology* for numerous fields and can make important contributions to new solutions for effective and affordable health care, highly functional sportswear and goods and smart personal protection. All these are rapidly growing markets and targeted by the European societal challenges of active ageing and safety and security. CONTEXT Cost Action [4] proposers defined *the following main technological challenges for textile materials in the healthcare and medical, automotive and aeronautic, sports, personal protection and building and living sectors*.

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Table (2): Key challenges by sector

Sector	Key challenges
Healthcare and medical	● development of controlled drug release fiber and textile structures for therapeutics of different skin conditions ● development of garments and home textile products with fully integrated bio- monitoring, active systems to improve life quality and ICT systems enabling remote monitoring of patients and assisted living services for "better ageing concepts" ● development of fiber and textile structures with enhanced thermal/breathability electro-active properties with integration of new surface functionalities for improving barrier (antiviral and antibacterial) properties
Automotive and aeronautics	● integration of fully integrated and printed electroactive and interactive sensors and actuators that enable the development of ubiquitous sensing and interactive surfaces, while also integrating fully embedded (or printed and/or fiber and yarn integrated) haptic feedback systems via both lighting integration and mechanical stimuli responses ● integration of fully customizable self- lighting materials based on active fibers and yarns, and integration or programmable textile matrixes for interactive sensing
Sports	● development of lightweight performance garments having new textile surface coatings enhancing thermal management (insulation), controlled drug release for muscle care, and also proving optimized comfort, low pill, low shrink and fast drying ● integration of low power/autonomous biomonitoring and/or integrated ICT and IoT communication systems for training monitoring and performance assistance and integration concepts of training analytics, always connected and data sharing for garment/textile structures "peripherals"
Personal protection	● the integration of geo tracking and personal GPS systems (Global Positioning Systems), physiological and biometric monitoring, embedded and integrated communications and energy harvesting, with all data monitoring systems sharing data in real-time ● integration of cooling/heating systems into garments
Building and living	● development of new functional textile materials using nanomaterials and industrial waste, eco-friendly technologies (like ultrasonic deposition, bi/tri- component fibers, UV curing coatings), considering multilayer approaches ● focus on high thermal performance (applying eco-efficient heating and cooling systems, together with low thermal conductivity and diffusivity coatings and additives, infrared reflective and phase change materials), to achieve Net Zero Energy Buildings (NZEB) ● textile functionalization with smart and efficient systems like sensorization, communication systems and actuators, considering printing electronics approaches, to maximize comfort, well-being ● develop interoperability between connected devices

2. Examples of success stories of EU SMEs/Start Ups

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2.1 Marina Textil

Figure (4) – Marina Textil headquarters (Source: Marina Textil)

Creation:1995

Location: Barberà del Vallès (Barcelona)

Activity: Manufacturing of technical textile products forpersonal protection.

Marina Textil is an example of how a company can detect market needs and, through innovation and transformation, turn its business around to meet them.

Beginning in 1995 with the aim of making fashionable fabrics, in less than a year they began working on the development of technical fire protection fabrics and other elements, leading to the creation of Marlan fabric, a fabric designed to protect against splashes of fusion metal. 10 years later, about 85% of its production was intended for fire-retardant fabrics, thus turning the company's main activity into the manufacture of technical fabrics.

Currently, Marina Textil has its own laboratories and manufactures all its fabrics, from warping to the finished product. Marina Textil has specialized to create different lines of personal protection products depending on the use and activity of the sector.

Two examples of this specialization would be Marina Racewear and Texfire companies, created within Marina group [5].

Figure (5) – Marina Race jumpsuit (Source: Marina Racewear)

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Marina Textil landed in the market of racing garments by creating a new company: Marina Race, making products such as racing jumpsuits, gloves, fireproof clothing, and all kinds of clothing dedicated to the competition and personal protection of this activity. It also has a subcategory dedicated to technical garments for professionals such as mechanics and other technical teams.

Figure (6) – Texfire chemical protection cover (Source: Texfire)

Texfire is another company within Marina group dedicated to the production of fabrics and products for the protection of people, objects and environments. Through innovation and technology, it develops different types of fire-retardant fabrics, such as fiberglass fabric, aluminized fabric, multilayer fabrics, or coated fabric. It also manufactures textile products with fire-retardant properties such as blankets, sleeves and welding protection equipment.

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2.2 Cebiotex

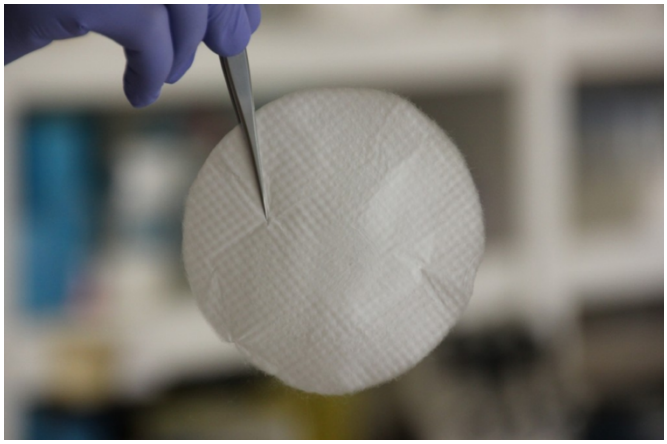
Figure (7) – Cebiotex logo (Source: Cebiotex)

Creation: 2012

Location: Barcelona

Activity: Manufacturing of biomedical textile nanofibers.

Figure (8) – Cebiotex's nanofiber (Source: Cebiotex)



Cebiotex is a biotechnological start-up originating in Barcelona from the collaboration between researchers from Universitat Politécnica de Catalunya (UPC) and Hospital Sant de Déu in Barcelona (HSJD). In order to provide biomedical solutions to cancer patients, Cebiotex developed the drug CEB-01, a patch-shaped membrane that is implanted at the point where the tumor has been removed, and that releases a drug to remove remaining cancer cells. What is intended to achieve with the application of this drug is to reduce the application of more aggressive treatments such as chemotherapy or radiation therapy, especially in child patients.

The project came from a very simple idea: Apply a tissue to the wound that releases the medicine. But developing it required a joint project between textile engineers (UPC) and other health sciences researchers (HSJD). The project is currently under trial, although the first results have been positive, and everything points to a promising outcome [6].

2.3 C.P. Aluart

Figure (9) – C.P.Aluart logo (Source: C. P. Aluart)

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Creation:1993

Location: Mataró (Barcelona)

Activity: Manufacturing of technical textile products for personal protection.

C.P. Aluart is another example of a company that, making use of its experience and innovation, took the opportunity to specialize in the manufacture of technical fabrics.Beginning in 1993 with the manufacture of fabrics and garments for the fashion sector, in a few years it started to manufacture a new equipment for the French fire brigade.From this moment on, the company took a new course towards specialization in the manufacture of technical fabrics and personal protective garments.

All production is local, allowing it to harness the potential of regional industry, and to innovate in new in-house fabrics. The range of fabrics it manufactures covers: breathable recycled fabrics, thermal fabrics, fireproof technical fabrics, antistatic fabrics and anti-cut fabrics.

Apart from the manufacture of technical fabrics, C.P.Aluart designs and manufactures personal protective equipment, focusing mainly on 3 divisions: Military and police protection workear; fire-fighters protective equipment and work protection equipment [7].

WORK PROTECTION EQUIPMENT

Figure (10) – Cut protection garment (Source: C.P.Aluart)

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Occupational protective equipment is designed to protect workers in their workplace, especially those working in the industrial sector. C.P. Aluart specializes in cutting, fire, electric arc and static electricity protection, and high-visibility equipment.

MILITARY AND POLICE PROTECTION GARMENTS

Figure (11) – High transpiration garment (Source: C.P.Aluart)

Military and police protection equipment is designed to offer maximum comfort to the personnel of these bodies in the performance of their activity. The offer ranges from high transpiration and thermal protection garments to high-visibility equipment.

FIREFIGHTERSPROTECTIVE EQUIPMENT

Figure (12) – Firefighter's protection garment (Source: C.P.Aluart)

Firefighters' protective equipment has fire-retardant qualities and protects their users from fire and electric elements. This equipment must fulfill very rigorous quality control before putting themselves into use.

2.4 Hilaturas Arnau

Figure (13) –Hilaturas Arnau logo (Source: Hilaturas Arnau)

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Creation:1947

Location: Sabadell (Barcelona)

Activity: Manufacturing of technical recycled yarns and sustainable yarns

Born in 1947, Hilaturas Arnau is still active today, producing and exporting yarns and fabrics with fashion and technical applications.

Starting by manufacturing yarns for fashion brands, it was not until the early twentieth century that the company began to introduce into its production system new technical fibers obtained by recycling bulletproof vests, which would be intended for industrial and protective uses. These technical fibers include anti-cut, or fire-retardant properties.[8].

Figure (14) – Cover picture for the Natural fiber's products line (Source: Hilaturas Arnau)

- Hilaturas Arnau has also innovated in the ecological aspect and has developed two textile production lines:
- Yarns and fabrics obtained by recycling raw materials. Whether from raw materials such as wool, silk, cotton, mohair, linen, or materials obtained from marine or terrestrial waste such as acrylic or polyester.

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- Natural yarns and fabrics obtained from biodegradable materials such as: bamboo, corn, hemp, pineapple, mint, among others.

2.5 LIASA -La IndustriaL Algodonera

Figure (15) – LIASA logo (Source:Liasa)

Creation:1918

Location: Selva del Camp (Tarragona)

Activity: Manufacturing of cord, elastic cord, **ribbon,** and polypropylene yarn

LIASA has been active for more than 100 years. It manufactures cord, elastic cord, ribbon, and polypropylene yarn that can be applied to several sectors, such as healthcare, packaging, or industry [9].

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APPLICATIONS IN THE HEALTHCARE INDUSTRY

Figure (16) – Surgical masks (Source: Liasa)

Manufacture of cords, elastics, bands, and elastic ribbons forhygienic or surgical masks, hospital protective clothing, protective face shields, and masks, among others.

TECHNICAL/INDUSTRIAL APPLICATIONS

Figure (17) – Workers of the industrial sector (Source: LIASA)

Manufacture cords, elastics, bands, shock cords, bungee cords, hard wearing ropes and ribbonsfor the technical and industrial sector. Main uses are: Protection for fruit fields, agriculture, automotive, building, personal protective equipment, beekeeping, among others.

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2.6 AidaNano

Figure (18) – AidaNano Celulose logo (Source: AidaNano)

Creation:2017

Location: Vilassar de Dalt (Barcelona)

Activity: Manufacturing of nano cellulose fibers.

Aida Nano is specialized in the manufacture of nano fibers made of cellulose. Nanofibers offer several features that make them a useful material in different industries. Qualities such as elasticity, porosity control, or their strength make them highly prized in the manufacture of technical textile products for sectors such as medicine, automotive, or construction [10].

Aida Nano has perfected, through innovation and specialized personnel, its production model to adapt its nanofibers to the application sector. Among these sectors, we highlight:

PACKAGING INDUSTRY

Figure (19) – Packaging plastic rolls (Source: Pixabay)

Companies are increasingly looking for alternatives to plastic. Nanofibers can be a good substitute as they are both efficient and leave no mark on the environment.

AUTOMOTIVE SECTOR

Figure (20) – Interior of a car (Source: Pixabay)

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Nanofibers are a lighter alternative than other materials and are currently being used in automotive to reduce the weight of cars and improve their components.

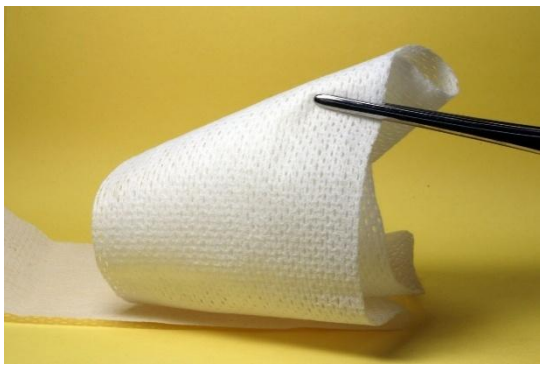
ELECTRONICS

Figure (21) – Solar Panels (Source: Pixabay)

Nanofibers have several properties that make them ideal for use in electronic applications such as power devices or sensors. High transparency and low coefficient of thermal expansion make them a good material in electronics.

MEDICINE

Figure (22) – Medical bandages (Source: Pixabay)



Nanofibers have great application potential in the field of medicine, and is common their use in sensors, antibacterial agents, wound bandages, tissue engineering, bridges for bone regeneration, and many more.

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3. Market info: trends and opportunities of advanced textile materials in Tunisia

According to the Tunisian investment Authority "Opportunities for Investors in Tunisia's Textiles Sector" report, we can retain the following figures:

- Confirmed expertise

Tunisia is ranked 1st in North Africa in terms of "General Expertise", A Confirmed Global Talent Competitiveness Index 2018

- A strong R&D Activities

Tunisia holds the greatest concentration of researchers among Arab and African countries, is the 1st producer of scientific & technical articles in North Africa and accounts for 50% of scientific publications in the region

- A strong capacity for innovation

Tunisia is the 1st most innovative economy in North Africa and the 3rd in Africa, Global Innovation Index 2020

- Availability of fresh graduates

Highly educated graduates available with +60,000 new graduates every year, of which 35% are graduates in engineering and Textiles related fields.

- Availability of managarial skills

Most foreign companies are 100% managed by Tunisian executives, Availability of demonstrating the availability of skills at all management levels in Tunisia

Tunisia is considered as a talent hub, ranking 1st in North Africa for graduate skills, access to skilled employees and labour cost

Textile niches

- High end Denim Manufacturing
- Knitted Garments and High-Performance Sportswear
- Technical & Functional Textiles
- Apparel Accessories
- Mid to high-end lingerie
- High Tech Workwear & Protective Clothing

The textie sector is a leading sector in Tunsia. Indeed, :

- more than 1,560 Companies of which 1,270 are producing for the export market
- more than 40% are foreign invested companies
- more than 30% of total employment in the industry
- more than 1/3 of industrial companies at 2021 Tunisian Investment Authority
- more than 160K employees
- more than 150K employees are working in export-oriented companies
- 95% of the sector's exports are destined for the EU Market

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- 28% Of value added in manufacturing
- (Source: National Institute of statistics, Tunisian Technical Center for Textile (CETTEX), Feb 2020)

Tunisian manufacturers are increasing in sophistication and are aiming to further attract high-end textile brands.

Increasingly moving towards manufacturing finished products focused on innovation and R&D, involved in the full process, from spinning through to weaving to finishing.

Innovative Ecosystem：

- 3rd most innovative economy in Africa
- 3.5+ M funding in 2020
- 169 technical and 135 financial support institutions as well as 22 facilitators
- 5th best start-up ecosystem in Africa

Attractive Incentives for Investors：

- Investment grants and grants based on job creation capacity -
- Freedom to hold 100% of the company's capital and to transfer profits and assets abroad in foreign currency
- Ranks 3rd in terms of business friendliness among African countries

Competitive Nearshoring Option：

– Large pool of highquality labour at low costs

– Low rents for office and industrial spaces as well as low utility costs

– Ranks 1st in terms of cost effectiveness among African countries

According to the deliverable D1.2 "Tunisian National report" :

The macroeconomic data on the textile sector clearly show the positioning of the textile and clothing sector as a pillar of the Tunisian economy. It represents, in fact, 30% of the industrial fabric and 31% of industrial employment in the country. The export value in textiles and clothing represents 20% of industrial exports, thus favouring a clearly positive trade balance. This industrial fabric ismainly characterised by a clear dominance of the clothing activity (warp and weft and knitwear) with low added value and engendering a preponderance of sub-contracting companies in the sector.

In the international context, textiles and fashion are oriented to eco-responsible fashion (ethic consumer), offer customization and fast-fashion. It is within this international context that the sector must fit in. The sector must answer to these new international orientations and improve its performances to remain competitive on traditional markets particularly the European market. On the basis of the acquired experience, the geographical proximity to European contractors, the availability of high-level technical skills and the commitment of the State to this high priority sector, the textile industry must activate the innovation lever to control its value

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chain, increase its added value and compete on the international market. Industry 4.0 and digitalisation are also development niches of this sector to be exploited.

The study also reveals the potential of the technical textile industry. Indeed, the technical textile industry is a rapidly growing sector worldwide and especially on the European market, which presents an opportunity to be seized. The integration of this high added value area and the establishment of the technical textile manufacturer's image is one of the most promising avenues with a high potential for innovation.

Among the cited ativities with a high innovation potential there are, in order of importance, technical textiles, finishing and clothing. Especially, the sustainability, the mass customisation, design, fast-fashion and integration of augmented reality are considered in many projects. On another note, fields with a high innovation potential in the textile and clothing industry are innovation processes, innovation management, innovation in products and new technologies integration.

Furthermore, in order to be able to innovate, the study revealed that industrialists call for the availability of specific research equipment and the availability of innovation skills, not to mention non-technological and transversal skills. The participants indicated that there is a need to enhance the universitiy-industry collaboration in the textile sector by establishing innovation centers

The focus group participants also emphasized on the importance of collaboration between Tunisian universities and the industry. It stressed the importance of establishing educational and effective training programs related to textile processing and manufacturing in Tunisian universities and be able to innovate, to communicate and create marketing content.

Those centers must be linked to the research part, to overcome the TRL 4 (lab approval level) to semi-industrial and further levels. In these centers, we need to develop samples and prototypes, to bring (R&D) skills, in innovation procedures.

4. Tech transfer services through WINTEX

4.1. Innovation centers concepts and services

The university-industry collaboration can be institutionalised by setting up a collaboration platform bringing together academics and industrialists with the mission of implementing an effective cooperation and research and innovation strategy. The creation of a textile academia council within the WINTEX project falls within this framework.

The centers will respond to the need expressed in the preparation phase mainly the lack of advanced equipment or its poor governance and exploitation seems to be the first obstacle for researchers. The unacquired skills in management and the set-up of research projects and programme exploitation were also cited by researchers as an obstacle to the development of research and innovation.

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Those centers will be pioneers in terms of innovation (a small number of Tunisian companies operating in the textile manufacturing sector does not prevent the multiplication of technological development projects in these areas)

Their mission is to facilitate the interaction between research (academic and research centers) and production (industry) in order to allow the knowledge generated and high-tech discoveries to reach society quickly and effectively. This interaction will facilitate the transformation of science and technology into strategic development variables. This center aims to increase the competitiveness of local textile clothing industry and emerging companies through training, licensing of new technology, promoting the scientific and research potential of the academy, and through presenting matching business partners.

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Facing increased competition for decades, the textile industry is developing a real strategy based on innovation. Tunisia, particularly affected by the decline in its ranking among the EU's suppliers of textile and clothing products over the past decade, but also endowed with remarkable potential, has embarked on this path.

The main objective of the textile innovation centers will be to stimulate and support the development of the textiles of tomorrow. These centers will form a link between university research and business.

The WINTEX project aims to fill the lack of specialized services in the Tunisian textile sector with the creation of three textile innovation centers located in the participating universities in Tunisia: University of Sfax, University of Monastir and the Higher Institute of Technological Studies of Ksar-Hellal (ISET).

These three centers will be equipped with high-tech equipment to promote innovation in close collaboration with textile companies within the framework of university-industry collaboration and the strengthening of technology transfer. This equipment is funded by the European Union to the tune of 300,000 Euros.

Table 1. Preliminary list of equipment for textile innovation centers to becreated as part of the Wintex project

ISET Ksar-Hellal Center	IS2M Center	ISAMS /USF Center
Electrospinning unit	Scanning electron microscope	3d Body scanner Cabine
Extrusion and meltblown die assembly		3D Simulation textile design software

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Web forming, edge-cutting & winding unit		Fabric scanner
Vacuum furnace and ultrasonic bath		Transfer printing machine
Labcalendering machine		3D print/CNC
Manual hot press		Head Laser Engraving Cutting Machine
Handtuftingequipement		Digital embroidery machine with software
Warping machine		Automatic lab Knitting flat machine

The equipment that will be supplied to the centers will meet certain needs and create synergies between these centers, thus optimizing the installed capacities. The main objective of the innovation centers is to support companies in the textile industry with advanced and specialized services. Staff from universities participating in the project will be trained in an international environment and will have access to the expertise of the European textile centers involved in the project.

The innovation centers will support companies in the textile industry, entrepreneurs who develop new solutions using cutting-edge textiles, students involved in start-ups as well as researchers seeking to enhance their results of research. The centers' business models will ensure their sustainability, regardless of the duration of the project.

The centers will offer the opportunity to provide new services to textile companies such as the prototyping of innovative textiles and the optimization of their performance, advanced quality controls, certification, specific trainings, workshops and seminars, support for projects, organization of events to encourage innovation, support for participation in exhibitions, promotion of entrepreneurship and the integration of innovative ideas in the textile industry.

Completely new services will be developed, such as quality testing, product certification, training, information seminars on fashion trends, new ways of organizing production, etc.

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Furthermore, new services will be developed, such as quality testing, product certification, training, information seminars on fashion trends, new ways of organizing production, etc.

The three centers will be equipped with additional equipment covering various technical textile specialties but always in a dynamic of smart and circular economy:

- Pilot lines for the development of nonwovens by dry process and by meltblown spinning intended for medical, industrial, automotive applications, etc.;
- Pilot lines for the development of composite textiles
- Machines to develop eco-designed products with high added value
- Computer-aided simulation and creation tools and software
- Design and fashion 4.0 equipment
- Advanced metrology and analysis devices

The three textile innovation centers will aim to respond to societal challenges related to Sustainable Development to transform the entire sector and:

- Make smart technologies accessible.
- Integrate digital transformation into business lines.
- Minimize its environmental footprint.
- Develop value ecosystems.
- Deploy new business models (functional economy, circular economy).

To achieve this, these centers should have:

- Adequate financial and technical support during all phases of implementation
- Effective governance, according to an adapted public-private model, guaranteeing financial autonomy, sustainability and the future development of these centers
- Qualified human resources working for the centers (by employment contracts to be defined later) and benefiting from a specific program of continuous training and skills building
- Close cooperation with the industrial fabric and all stakeholders in the Tunisian textile sector on development work and prototyping of innovative products and processes, technology transfer projects and prospecting for new niches in the textile of the future.

These innovation centers will be overseen by an academic textile council whose objectives will be:

- Become a pole of R&D competences and a leading technological platform in Tunisia in the field of technical textiles and innovative textiles
- Lead a network of 3 textile innovation centers in ecosystems very active in the field of training textile manufacturers, with recognized expertise and full of great potential for innovation
- Involve large Tunisian partner companies in governance
- Host an on-site workforce of around one hundred people divided between:

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- R&D activity and technology transfer
- Academic research
- Valuation ecosystem

- Generate startups on innovative textiles and incubation companies
- Prospect funding and attract international partners for cooperation projects on themes related to innovative textiles
- Federate a network of growing regional textile-clothing SMEs thanks to innovation
- Encourage the creation of direct jobs in the field of innovative textiles.

During the implementation of the Wintex project, a collaborative platform could be set up online, a virtual space aimed at promoting collaboration between:

- The textile innovation centers established at ISET, ISAMS and IS2M;
- Centers and companies belonging to the European and Mediterranean region;
- Centers and other stakeholders, such as legislators, BIOs and research centers;
- Centers and initiative groups which intend to create other textile centers and / or universities which wish to establish textile centers.
- The upcoming platform will provide a space to learn about activities, events, projects, funding opportunities and to access different types of useful links.

The complete setup of the three INNOVATION TEXTILES' CENTERS: that ofISAMS/ USF, that of ISET KH and that of UM/IISMM to provide services to textile companies and to be used as a support for education of bachelors and master's students in each HEI. Those centers will also include a set of services that will be validated during the project as part of a pilot program. The optimized set of services along with a sustainable business model that will be develop and validated will remain active beyond the project end. Each HEI will have their own strategy for their center.

To sum up the proposed innovative services that will be offered to Tunisian textile sector through the establishment of the Innovation Textiles' Centers among others:

- Information about new technology trends,
- training in innovative and environmental friendlier manufacturing techniques,
- innovative ways of organization of production,
- certification of products,
- ways to lower production costs and increase of productivity,
- development of quality products,
- information about investment and funding opportunities,
- support and training to students willing to innovate in the field of textiles.
- support scientists through continuing education, seminars, conferences, and consulting services, Applied research and technology development.

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4.2. Sustainability of the innovation centers

According to the deliverable D. 1.4 the "conclusions and recommendations report", the business sustainability is directly related to business models and managerial decisions grounded in financial, environmental and social concerns. It is important to:

- Create financial value,
- Knowhow their actions affect the environment and actively address those impacts,
- Care about their employees, customers and communities and work to make positive social change,
- Give visibility and improve the presence of these centers on the real (trade shows, fairs, etc.) and virtual spheres (site referencing, newsletters, presence LinkedIn, etc.)

Compared to companies that focus on short-term profits and make decisions based solely on the bottom line, sustainable companies think long term. They forge strong relationships with employees and members of the community. They find ways to reduce the amount of natural resources they consume and the amount of waste and pollution they produce. As a result, sustainable companies survive shocks like global recessions, worker strikes, executive scandals and boycotts by environmental activists.

The centers' staff will be trained in innovation and technology transfer. Capacity building includes study visits and training.

The activities of building capacity in higher education are:

- Development of blended training program for Technology transfer Officer, based on the training program. The program will have an e-learning part followed by a face-to-face workshop.
- Development of training program for Innovation Lab facilitator, based on the training program of the EU project I-Lab.
- Organization of training courses. Output: One program for Technology Transfer, e-learning and workshop in Spain, Greece, Italy and Romania during the project meetings
- Organization of study visits.

The design and research centers staff will get better conditions to facilitate the access of companies to research results. This will improve the innovation capacity building (both technical and managerial) of local communities, because through aggregation models (productive districts, technology clusters, academia-industry partnerships) innovation ecosystems will be supported, new business investments will be encouraged and the whole territorial system will become more stable, dynamic and mature, thus generating qualified jobs and slowing the brain drain process.

In general terms, within a global framework in which the speed of the connection between knowledge and market is decisive to sustain innovation, the project intends to give a contribution to how to implement an efficient and effective use of knowledge for the generation of economic value.

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The project objective of setting up innovation textiles' centers at each HEI in Tunisia will provide with modernized infrastructure and equipment that will benefit the HEI in several aspects including technical capacities to provide services to the textile sector and modernize equipment for teaching purposes within their current programs (for instance having traineeships and internships of students within the centers).

The equipment that will be installed will be validated during the preparation work package allowing targeting specific regional needs and aligning with the overall institutional strategy for modernization.

The establishment of centers is aligned with the Tunisian national policy of HEI development for competitiveness increase by facilitating the skill matching with the industrial needs.

In addition, the active leadership of USF, ISET and ISMM in the Academia Textile Industry Council will also favor the flourishing of cooperation among the different HEIs and with industry at large, generating trust and joint agendas for further investments.

Finally, the aim of the centers is to play a cooperative role with other research and support structures and not to compete with them.

As recommendation, status of the centers needs to be defined: legal status, remuneration of employees and service providers, etc.) to ensure the sustainability of these centers

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6. ANNEXES: Guidelines to start a startup in Tunisia / Other national services for entrepreneurs in Tunisia

5.1. Guidelines to start a startup in Tunisia

1. Law n° 2018-20 of April 17, 2018 relating to startups in Tunisia

https://startup.gov.tn/sites/default/files/2022-01/Decret2018_840Arabe.pdf

2. Decree No. 2018-840 of October 11, 2018 setting the conditions, procedures and deadlines for granting and withdrawing the startup label and the benefit of incentives and benefits for startups and the organization, the prerogatives and terms of operation of the labeling committee.

https://startup.gov.tn/sites/default/files/2022-01/Loi2018_20.pdf

3. Circular of the Central Bank of Tunisia n° 2019-01

https://startup.gov.tn/sites/default/files/2022-01/Cir_2019_01_ar.pdf

4. Circular of the Central Bank of Tunisia n° 2019-02.

https://startup.gov.tn/sites/default/files/2022-01/Cir_2019_02_ar.pdf

5.2. Other national services for entrepreneurs in Tunisia

Public structures for supporting innovation in the textile sector

APII: The Agency for the Promotion of Industry and Innovation with its various support and willfunding mechanisms supports the textile and clothing industry to improve its competitiveness and innovation. The APII is responsible for supervising and helping textile and clothing companies to identify their needs in terms of technological innovation and work to promote the results of research and technology transfer. It is responsible for disseminating the culture of technological innovation through the popularization of programs and mechanisms related to innovation and the valorization of research results.

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Technical center of textile (CETTEX)[1]: An establishment of public economic interest under the supervision of the Tunisian Ministry of Industry and SMEs. Created in 1991, it provides advice and expertise to manufacturers and public authorities in the Textile and Clothing sector. CETTEX offers operators a complete range of services: technical assistance in textiles production, research and development, analysis and testing in laboratory, professional training and competitive intelligence. It supports Tunisian textile companies in their technical, managerial and organizational development and assist them in their growth and innovation process.

National Agency for the Promotion of Scientific Research (ANPR): An agency under the supervision of the Ministry of Higher Education and Scientific Research. It provides textile research structures to companies as well as support to carry out their research programs.

National Institute for Standardization and Industrial Property (INNORPI): Researchers in the textile field use INNORPI to register their patents. This action will protect the inventor's intellectual property. Another important mission of INNORPI is to provide researchers with national testing standards.

a. Programs Innovation offer

In terms of tools for encouraging and financing innovation, Tunisia is positioned among the southern Mediterranean countries with the most numerous and diversified financing mechanisms.
Public financing tools are available upstream at the level of research laboratories, as well as for companies with R&D programs.

- **Incentive programs and innovation funding [2]**

Tunisia's innovation financing system includes a wide range of financial support instruments. These instruments cover the entire process, from the project idea to commercialization and, if necessary, the creation of the company. These instruments, implemented in stages, are constantly evolving. These instruments are managed by public structures, private structures or non-governmental organizations.

These funds or funding mechanisms can be grouped into three broad categories: individualized support, incentives for collaborative research, and equity support for entrepreneurial developers (Figure.5).

Research incentive programs are funds intended mainly for research structures. They include, as for example the following programs: federated research projects (PRF), projects to encourage young researchers (PEJC), projects to encourage young teacher-researchers (PEJEC), the POST

1

www.cettex.com.tn

2 Innovation Guide, APII

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PFE program, ... These funds are managed by the Ministry of Higher Education and Scientific Research.

The implementation of Federated Research Programs (PRF) aims to mobilize skills and create synergies between research structures and their partners, public or private, concerned with the development of the scientific research and technology sector. The PRF deal with national priority themes defined in consultation with the various operators in the sector concerned. The objective of the programs for the encouragement of young researchers is the promotion of diplomatic research in strategic areas through the establishment of incentive mechanisms for the benefit of student researchers.

There are other incentives, particularly in the context of higher education modernization projects such as the PAQ d'appui à la qualité d'enseignement supérieur project published by the MHESR, namely PAQ post PFE and PAQ collabora. These incentives aim to finance the best end-of-study projects in order to move from study to realization.

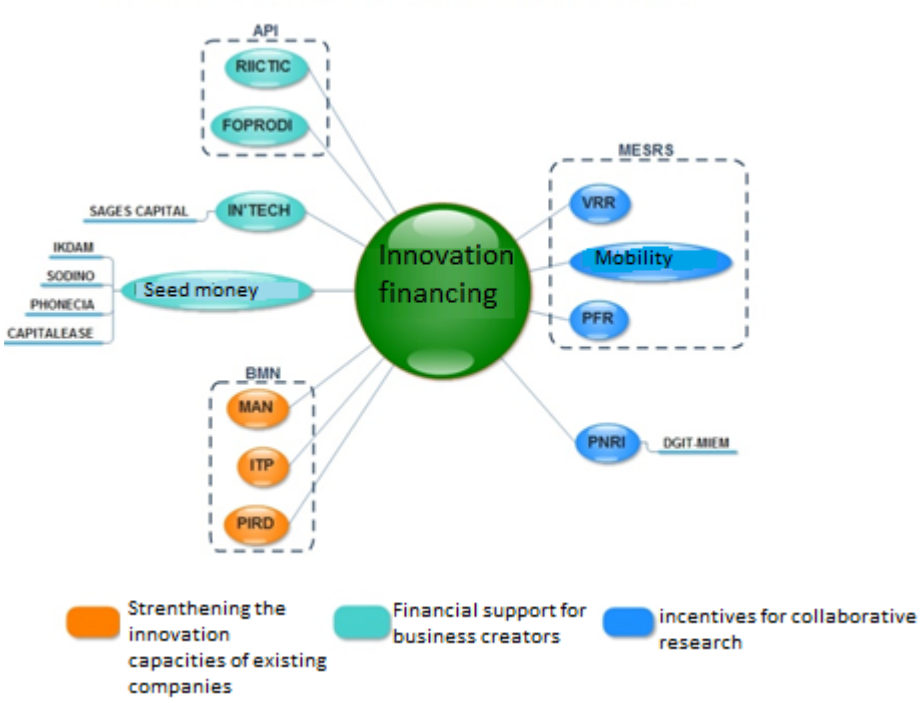

Figure 5.Mapping of research and innovation mechanisms in Tunisia

A second set of incentive programs is aimed at cooperation between companies and research structures, namely: The National Program for Research and Innovation (PNRI), the Research Valorization Fund (VRR), and programs for the mobility of researchers (MOBIDOC, POSTDOC). These programs aim to strengthen collaboration between the industrial and research sectors in the field of research and innovation.

Existing companies benefit from several innovation incentives programs such as the Upgrading Program (PMN), Priority Technology Investment (ITP), the Research and Development Investment Premium (PIRD) and the Service Vouchers.

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Support for the creation of innovative companies are intended to support the creation of innovative companies by financing certain stages of the innovation process. They intervene at the level of the constitution of equity capital or the consolidation of the financial structure of the "start-up" by means of bank loans. In this 3rd category, we distinguish the following instruments: the funds for industrial promotion and decentralization (FOPRODI) and the incentive scheme for creativity and innovation in the field of ICT (RIICTIC), seed funds (IKDAM, Phenicia Seed Fund,...), venture capital mutual funds (FCPR) spin-offs, venture capital investment companies (Sicar), the Banque de financement des PME (BFPME) and the Société tunisienne de garantie (Sotugar), the tunisian solidarity bank (BTS - microcredit).

b. Innovation policy in Tunisia[3]

The innovative entrepreneurship system in Tunisia could only be understood, in all its dimensions, by going back to its origins and to the changes it has undergone for more than 30 years. Indeed, the desire to improve the business environment in Tunisia dates back to the financial crisis of the mid-1980s, when the Government decided in 1986 to initiate a "Structural Adjustment Plan", accompanied by a policy facilitating the creation of companies to boost investment.

Two important facts mark this policy, and their impact continues until now:

- Establishment of the "one-stop shop" for business creation within the APII, recommended in April 1989 and officially created in January 1991[4];
- Establishment of a Presidential Grand Prize rewarding administrative innovation initiatives[5], by a 1989 decree, still in force.

If the one-stop shop has had an indisputable impact on the performance of the business creation process - which can be done today even remotely[6] - the same cannot be said for the improvement of the business climate (which was weakly impacted), as one cannot speak of genuine innovative achievements within the Administration, for lack of a far-sighted and daring policy in this area.

Furthermore, if the government of the time relied on innovation as an accelerator of administrative reforms, it was not a forerunner in making innovation a factor in the competitiveness of companies and therefore a lever of economic growth.

Thus, although innovation was not expressly targeted by any text until the end of the 1990s, it has become embedded in most support instruments, in particular for:

- Product development projects (PMN-FODEC);
- Projects for the promotion of research results (VRR);
- Priority technological investment projects (ITP-FODEC);

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[3]Mustapha BOUBAYA, State of play in Tunisia: Actors, legislativeframework and financial instruments to encourage SMEs to innovate in Tunisia; September 2014.

[4]Decree No. 92-126 of 20 Jan. 1992 establishing the organization of the API (arts. 15 to 19).

[5]Decree No. 89-1958 of December 23, 1989, establishing the Grand Prize of the President of the Republic for administrative innovation. (JORT n ° 88 of December 29-31, 1989).

[6]Law n ° 2004-89 of 12/31/2004, relating to the procedures for the incorporation of online companies.

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- Technological investments linked to the creation of companies (ITP-creation);
- Design studies for new products and processes (PIRD).

This rather slow evolution, combining the need for technological mastery and the companies' concern for competitiveness, was not the result of a real strategic vision, not even the result of a clear and planned policy to promote innovation in the entrepreneurial landscape.

The construction of the innovation system has continued over the past two decades, during which 4 new instruments have been put in place:

- The mobility of MOBIDOC researchers, in 2002, to enable them to assist or create "innovative projects": a term expressly used for the first time[7];
- The PNRI National Research and Innovation Program, set up in 2003[8] by the Ministry of Higher Education, to finance collaborative research projects aimed at promoting technological development;
- The "seed funds" created following the promulgation of 2 laws in July 2005[9];
- The "IN'TECH" Fund created in 2009 under the Law of Dec. 2005 on FCPRs[10].

Finally, the national innovation system benefited, from the mid-2000s, from 3 support programs which mainly benefited industrial companies and industry-related services, namely:

- The Industrial Modernization Program, PMI funded by the European Union during the years 2004-2009, which introduced innovation in the coaching component;
- The Entrepreneurship and Innovation Support Program, PAEI funded by GTZ-GIZ;
- The Research and Innovation System Support Program, PASRI funded by the European Union.

These 3 programs significantly impacted the evolution of the system from 2010, a year which also saw the revision of 3 financial instruments to encourage innovation (RICITIC, PIRD and PNRI) and theirtransfer to the Ministry of Industry as well as the introduction of the IN'TECH Fund.

i. The national research and innovation system SNRI

Being one of the main ways to gain a competitive advantage, research / innovation has become a sine qua non for a successful economy. When an economy is innovative, it is more open to new ideas and technology, which requires a well-defined system.

Tunisia, aware of the difficult geoeconomic context, which sees the country increasingly face competition from Asia, has stepped up efforts to improve the national research and innovation system, both from the point of view of the attribution of responsibilities, and the one of the implementation of mechanismsfor its development and promotion. The Tunisian national system is still a young system, but with interestingpossibilities.

[7]Consecrated by Law n ° 2002-53 of June 3, 2002 (amending the Orientation Law on scientificresearch) and organized by decree n ° 2002-1573 of July 1, 2002.

[8]Program governed by decree 2011-1084 of July 29, 2011 establishing the PNRI and setting its conditions and procedures for intervention.

[9]Law n ° 2005-58 of July 18, 2005 relating to seedfunds and Law n ° 2005-59 of July 18, 2005 relating to tax provisions to encourage the creation of seedfunds.

[10]Law n ° 2005-105 of December 19, 2005 relating to the creation of risky mutual funds.

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Implementation structures

- 13 Universities + DGET
- 203 Higher education and scientific research establishments
- 277 Research Laboratories (LR)
- 304 Research Units (UR)
- 70 Common Service Units for Research
- 37 Doctoral Schools
- 38 Public research establishments CR.

Support structures

- DGRS: General Directorate of Scientific Research
- DGVR: General Directorate for the Promotion of Research
- ANPR: National Agency for the Promotion of Scientific Research
- CNEAR: National Committee for the Evaluation of Research Activities
- INNORPI: National Institute for Standardization and Industrial Property.

The university ecosystem suffers, however, from a poor match between the number of university graduates (53,000 per year) and market needs (12,000 per year, of which 80% go to the public sector).

The need for highly qualified researchers in technical fields will continue to grow to support innovative capacities and the creation of companies operating in applied sciences, engineering, energy, environment, ICT and medical applications. Research networks represent an opportunity for young Tunisian researchers to join research communities abroad and to excel in the development of their innovation capacities.

National Research& Innovation Program (PNRI)	Directorate-General for Innovation and Technological Development - Ministry of Industry	- Organic law of the state budget n ° 67-53 Decree 2011-1084 of July 29, 2011 relating to the creation of the PNRI and setting its conditions and modalities of intervention.
R&D investment premium (PIRD)	Upgrade Office - Ministry of Industry	- Investment Code (article 42) & Orientation Law No. 96-6 of 31-01-1996 relating to scientific research. Decree No. 2010-656 of April 5, 2010 on the granting of the bonus.
Seed funds (IKDAM, PHENICIA, CAPITAL EASE)	Company IKDAM-GESTION Alternative Capital Partner Company UGSF Company	- Laws 2005-58 & 59 of July 18, 2005 on Seed Funds. Decree 2005-2603 of September 24, 2005 implementing Law 2005-58.
Venture Capital – SICARs encouraged to invest at least 30% of their resources in new technology projects	42 SICARs (Venture Capital Investment Companies), created to help make investments intended to promote technology or itsmastery as well as innovation in all economic sectors.	- Law nº95-87 of October 30, 1995 - Law 2000-98 of December 25, 2000, on the 2001 Finance Law encouraging SICARs to finance innovative projects.

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FOPRODI – Industrial decentralization promotion fund	Industry and Innovation Promotion Agency (APII)	Laws: - Law 73-82 of 31-12-73, on the finance law for 1974 - Investment Code (Law 93-120 of 27-12-1993) - Law 2007-69 of 27-12-2007 relating to economic initiative - Law 2007-70 of 27-12-2007 on the 2008 finance law. - Code of UCI Collective Investment Bodies (Law 2001-83 of July 24, 2001). - Law 2005-105 of 19 Dec. 2005 on FCPRs. Decrees: 19 implementing decrees (from that of June 9, 1978 to that of Sept. 28, 2009), including 16 decrees in force.

Useful Addresses

GOVERNMENT/PUBLIC AUTHORITIES

Ministry of social affairs-General Direction of labour Inspection and Conciliation (GDLIC)

APII (Agence de Promotion de l'industrie et de l'innovation) Agency for promoting industry and innovation

EMPLOYER ORGANISATIONS

FTTH (Féderation Tunisienne du Textile_habillement) Tunisian Federation of Garment

Conect (Confédération des entreprises citoyennes de Tunisie)

TRADE UNIONS

Fédération tunisienne du textile, habillement, cuir et chaussures (Tunisian Federation of textile, garment, leather, and shoes)

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