The Age of Exponential Technological Changes

Contents

Executive Summary

1   **Introduction**

The Innovation and Technology Community ("InnoTech") was founded in 2011 within Ambrosetti Club, with the aim of contributing to the **creation of an effective and competitive innovation ecosystem in Italy.**
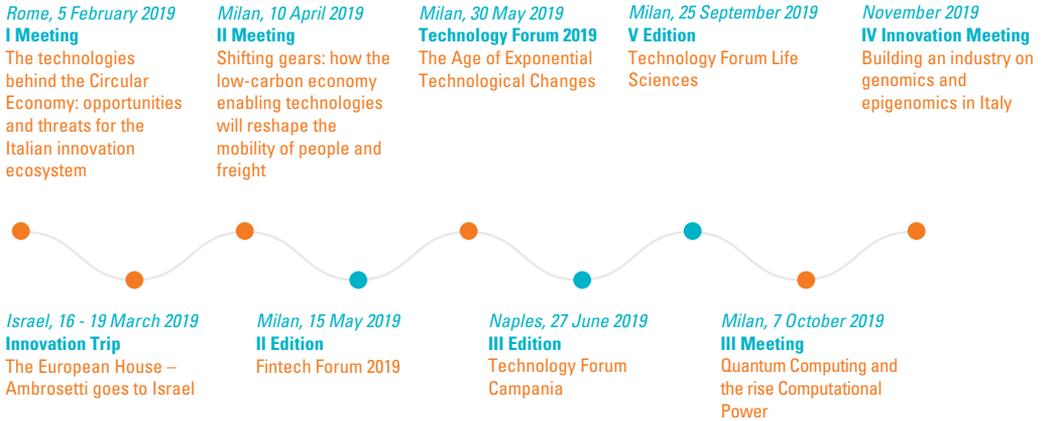
Ambrosetti Club, founded in 1999 and aimed at the top managers of national and multinational groups and companies operating in Italy (today it has more than 350 members), pursues several goals, including contributing to the civil and economic progress of Italy in an era of global competition.

The Community is an open system that brings together the contributions of different actors, from the public and private sectors, who give voice to their experiences, sharing best practices, as well as areas and methods of intervention with a positive and constructive spirit. The InnoTech Community aims to support the actions of Italy in one of the most important "building sites" for competitiveness today: the innovation ecosystem.

The cornerstones of the InnoTech Community activities are:
1. to **discuss the aspects of innovation** as growth factors with a pragmatic approach;
2. to **explore the benefits** that innovation and Technology Transfer can offer to companies;
3. to **share the most significant experiences** and best practices;
4. to **deepen the knowledge** of the most recent innovations and technologies;
5. to **share any reflections to the Italian policymakers,** in order to **stimulate debate and action.**

Every year, the Community plans a series of studies and events, in addition to in-depth meetings with leading figures in the Italian and international innovation scene. The meetings, attended by eminent entrepreneurs, experts and opinion leaders, aim to study the main issues in the Innovation and Technology field, creating moments of dialogue and exchange of knowledge and experiences, and to develop ideas and guidelines to submit to the attention of national decision makers.

Rome, 5 February 2019
I Meeting
The technologies behind the Circular Economy: opportunities and threats for the Italian innovation ecosystem

Milan, 10 April 2019
II Meeting
Shifting gears: how the low-carbon economy enabling technologies will reshape the mobility of people and freight

Milan, 30 May 2019
Technology Forum 2019
The Age of Exponential Technological Changes

Milan, 25 September 2019
V Edition
Technology Forum Life Sciences

November 2019
IV Innovation Meeting
Building an industry on genomics and epigenomics in Italy

Israel, 16 - 19 March 2019
Innovation Trip
The European House – Ambrosetti goes to Israel

Milan, 15 May 2019
II Edition
Fintech Forum 2019

Naples, 27 June 2019
III Edition
Technology Forum Campania

Milan, 7 October 2019
III Meeting
Quantum Computing and the rise Computational Power

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The main global innovation macro-trends for a sustainable future

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The combination of scientific progress, increased wealth - which leads to better living conditions - and low rates of early mortality have led **global life expectancy to reach, at 72 years[1], the highest level ever recorded since the 1960s**. The **world's population is growing at an annual rate of 1.2% and it will reach 9.7 billion by 2050**, 80% of which will **be concentrated in Africa and Asia**, and nearly 70% in urban areas.[2]

The increasing concentration of population in urban areas has led, over the years, to the emergence of **mega-cities**, urban conglomerates with more than 10 million inhabitants: in 1965 there were 3, today there are 33 and in 2030 there will be 43, mostly located in Asian countries. **(Figure 1)**

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1   Source: The European House - Ambrosetti based on World Health Organization data, 2019
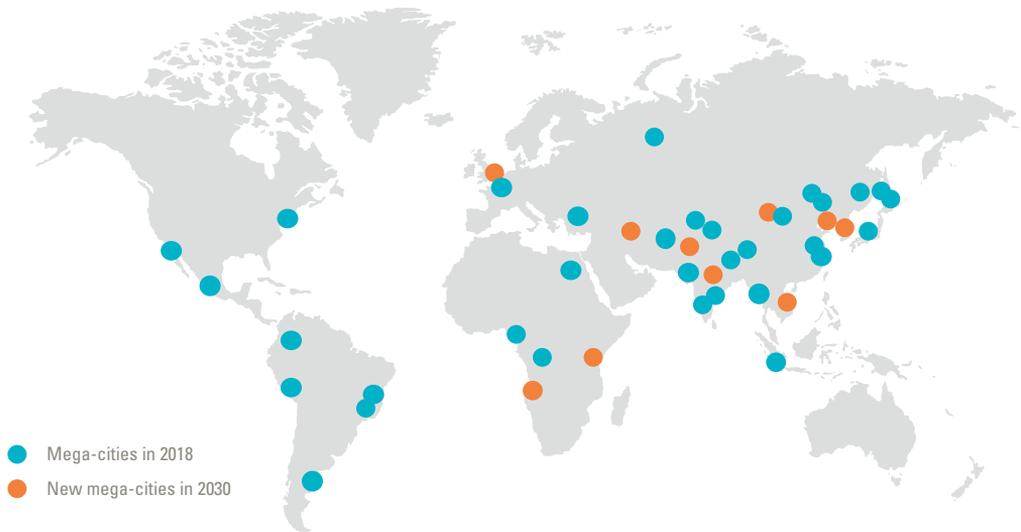2   Source: The European House – Ambrosetti based on United Nations data, 2019

Figure 1 |
Mega-cities in the world, 2018 and 2030. Source: The European House - Ambrosetti, based on UN data, 2019

The evolutionary dynamics of the world's population present challenges that both developed and developing countries cannot underestimate. Among the most important are:

- **overpopulation** and other issues related to the management and organization of housing;
- the need to develop **new transport channels**;
- managing **energy consumption**;
- managing **waste**;
- managing **environmental and air pollution**;
- an increased **demand for services management**;
- managing an **ageing society**;
- **increasing the resources needed** to meet the needs of the population.

In order to face the challenges that will arise and seize new opportunities, it's important, first of all, to rethink cities in a smart way, ensuring that they are well interconnected and therefore can give rise to a reactive and functional concept of urban and suburban space, a totally different model from the traditional ones.

Smart Cities for a sustainable urban ecosystem

businesses and Institutions must develop **new strategies to ensure the sustainability of cities and maximize the efficiency** in the management of the available resources. There are five main activity areas that can help transform a traditional city into a smart one: **mobility, buildings, services, people, and governance**. **(Figure 2)**
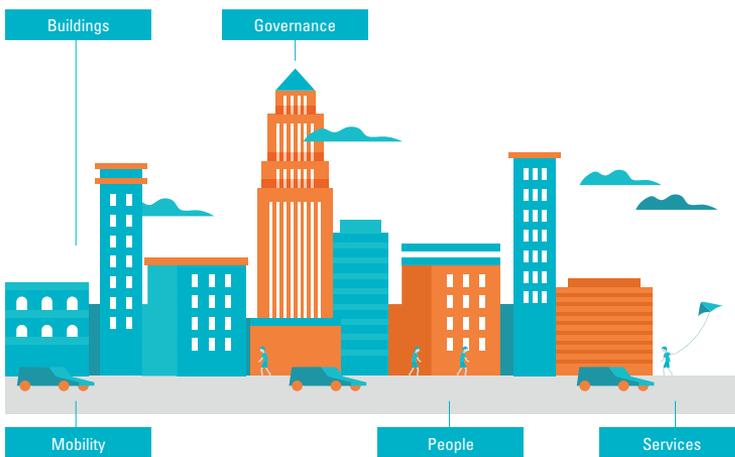

**Figure 2 |** Key elements of a Smart City. Source: The European House - Ambrosetti, 2019

In order for the cities of the future to be actual "Smart Cities", the basis of the realization of these ecosystems must be the provision of **technological infrastructures** that can support the exchange, at all times, of huge amounts of data, to ensure that people and objects are constantly interconnected and able to work seamlessly: 5G and 6G networks, Artificial Intelligence, Robotics, Blockchain, Quantum Computing are the technologies that will have an increasing impact in the cities of the future.

4 The Circular Economy as an enabling factor for Smart Cities

The success of a Smart City is based on the creation of a **circular model of resource management**, which provides for the reuse in the economic cycle of most production inputs, thus reducing the consumption of raw materials and the production of waste. Moving from a linear economy, which procures raw materials, transforms them into products that are used and disposed of as waste, to a circular economy, which instead reuses or recycles a part of the products or their components, allows to reduce both the consumption of raw materials and the production of waste, with advantages in terms of exploitation of primary resources (water, air, and soil) and environmental impact (less need for transport, mining and production activities). **(Figure 3)**

Figure 3 |
The Circular Economy model. Source: The European House - Ambrosetti based on the European Commission data, 2019
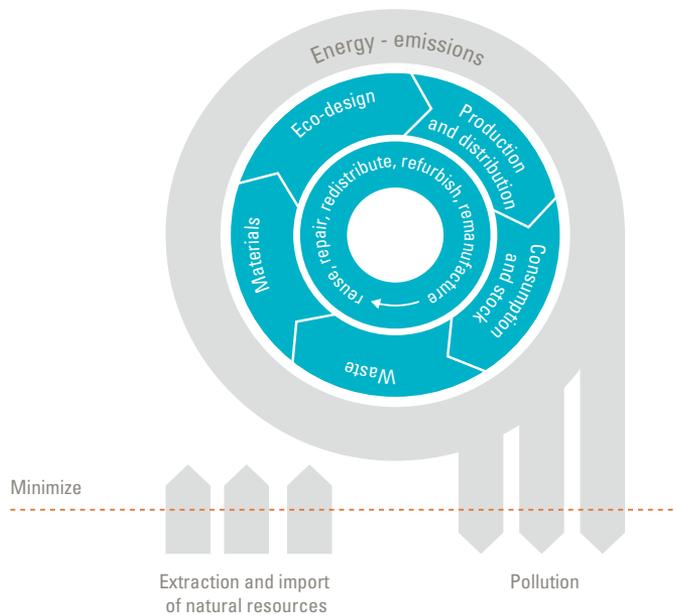
The Circular Economy, in fact, **enables sustainable development** not because it limits the consumption of products and services, but because it tends to minimize the productive inputs of raw materials, natural resources and energy, maximizing instead the use of innovative and sustainable resources.

Artificial Intelligence: why is there so much hype today?

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Artificial Intelligence can be considered as a "family" of technologies that **allows to identify correlations and patterns not perceptible by human beings**, through the processing of huge amounts of data.

Today there are examples of single activities that Artificial Intelligence can already perform better than humans or others that it performs almost as well as people, such as image recognition or text translation. **(Figure 4)**
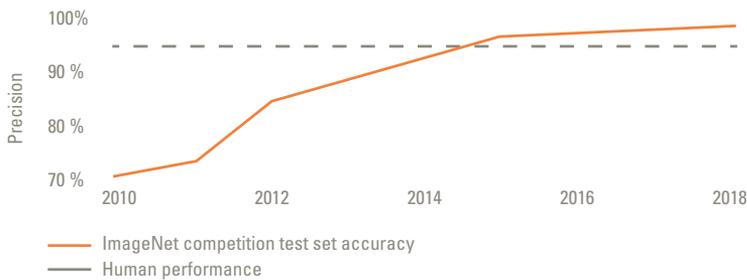
Figure 4 |
Precision rate of the algorithms for recognizing objects from photos and videos. Source: The European House - Ambrosetti based on Stanford University data, 2019

The great improvements and evolution of Artificial Intelligence took place when there was an opportunity to develop, on the one hand, an immense amount of data and, on the other hand, the ability to process this data at a very low cost and extremely quickly - the time needed to train a network on the ImageNet image database has decreased from about 1 hour to 4 minutes between mid-2017 and late 2018. **(Figure 5)**
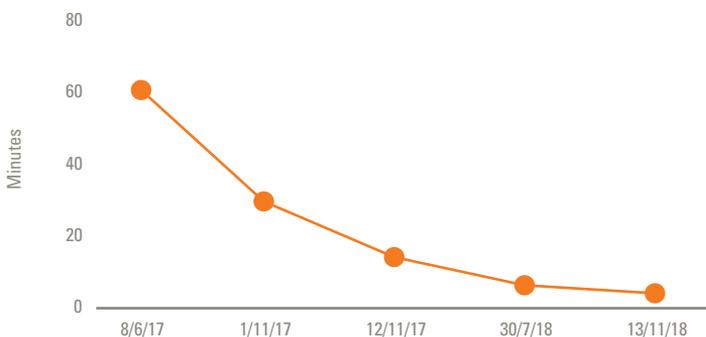
Figure 5 |
The amount of time it takes to train a network to classify images from the ImageNet database with a high degree of accuracy. Source: The European House - Ambrosetti elaboration on Stanford University data, 2019

Factors affecting the reduction of these timeframes include both algorithmic innovations and infrastructure investments. The evolution of Artificial Intelligence has accelerated thanks to:

- the **explosion of computational capacity,** achieved in particular with the use of GPUs (Graphics Processing Units), processors capable of performing extremely large amounts of operations in parallel, fast and consuming less energy than traditional CPUs (Central Processing Units), which are instead optimized to work on sequential tasks;

- the development of **new techniques of automatic learning** (Machine Learning or ML), based mainly on neural networks, which discreetly simulate the functioning of the brain: in particular, building huge neural networks both in terms of layers and "neurons", and then exposing them to huge amounts of data (Deep Learning or DL).

6   Competition in Artificial Intelligence

The spread of Artificial Intelligence implies a possible **discontinuity in the way we interact between human beings and consume the Planet's resources,** also affecting people's perception of the quality of life. Moreover, we must not forget that the development of Artificial Intelligence has a very significant military value as well. It is not surprising, therefore, that many countries are competing for the leadership in this technology, which has acquired today an unprecedented "geo-strategic" importance.

Many of the world's leading governments are moving to keep up with the times: China, United Kingdom, France, Germany, Finland, Canada, Japan, South Korea, India, Singapore, Mexico, Kenya, Tunisia and the United Arab Emirates, among others, have published **national plans to promote the development and use of Artificial Intelligence**. Each of these plans is based on the country's strengths and only a few, such as those of China and France, have since evolved into actual national strategies, while the other countries have limited themselves to publishing guidelines.

In December 2018, **the European Union published the "Coordinated Plan on Artificial Intelligence"**, which encourages all European Member States to develop their national strategies on Artificial Intelligence by 2019. Overall, the ambition is for Europe to become the world's leading region for the development and deployment of cutting-edge, ethical and safe Artificial Intelligence, promoting its human-centered approach worldwide. The European Union is investing heavily in Artificial Intelligence: the EU has committed €1.5 billion to fund Artificial Intelligence research over the 2018-2020 period, under the Horizon 2020 program. The EU expects the total public and private investment of the member countries to reach at least €20 billion Euros per year from 2020[3].

In Italy, the so-called **"Italian Strategy for Artificial Intelligence"** is currently being drafted (May 2019) through the support of a working group of 30 experts selected by the Ministry of Economic Development, so as to achieve the goal set by the European Union to launch this Strategy by 2019.

The risks associated with Artificial Intelligence

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Research in the field of Artificial Intelligence is advancing rapidly. In recent years, great progress has been made in image and voice recognition, autonomous robots and gaming. All this can lead to great benefits, such as new scientific discoveries, better and cheaper goods and services, and medical advances. But it also raises **short-term concerns: privacy, prejudice, inequality, security and protection**. In addition, an increasing number of experts inside and outside the Artificial Intelligence sector are concerned that future developments of this technology may pose long-term risks to the security of people, infrastructure and countries.

In the short term, research in the field of Artificial Intelligence is guided by the goal of maintaining a positive impact on society, in the economy, in the regulatory framework and in the techno-

3   Source: The European House - Ambrosetti based on "Digital Single Market - Artificial Intelligence" data, European Commission, April 2019.

logical arena. A risk that has many worried is that Artificial Intelligence may lead to the development of autonomous weapons, hence, today, a global arms race for the development of weapons based on Artificial Intelligence systems is a real risk. The long-term challenges for this technology concern the type of Artificial Intelligence known as **Artificial General Intelligence (AGI)**. There is concern about what would happen if an Artificial Intelligence were to be developed and it being better than humans in all cognitive tasks. Such a system could potentially undergo a recursive self-improvement, triggering an explosion of intelligence and leaving the human intellect far behind; in that case the technological development of our civilization would have reached the so-called technological singularity. It is therefore necessary to ensure that **Artificial Intelligence systems are bound by solid ethical frameworks, beneficial to humans**: Artificial Intelligence systems must do exactly what they are programmed to do by people, and not swerve out of their programmed path, albeit to reach the goal they were programmed for.

Artificial Intelligence is currently used in almost all economic and industrial sectors and, with its increasing use, digital security and global security issues are becoming increasingly central. The growth in efficiency and computational capacity has enabled the development of more efficient business models and solutions based on Artificial Intelligence for purposes such as the identification and prevention of cyber threats and cybercrime. While this technology offers many new opportunities, it opens the door to misuse of technology, as criminals are equally adept at using it to achieve their own goals; hostile operators can, in fact, directly attack Artificial Intelligence algorithms and try to enslave them to their own goals. Applications that use these technologies must therefore be designed following the **paradigm of "security by design"**, as well as regularly tested and updated. The future of cyber security and the fight against cyber-warfare will however be centered on the use of Artificial Intelligence to predict threats and react accordingly.

Scenarios and applications enabled by Smart Materials and other new materials 8

Progress in the development of new functional materials plays a vital role in solving many of today's global challenges, such as energy production and management, sustainability, medicine and health. Sentient materials, or as they are more commonly known, **Smart Materials,** may sound like "science fiction", but they are rapidly becoming a reality. Smart Materials are materials with one or more **properties that can be altered or controlled by external stimuli,** such as external actions (stress), temperature changes, humidity, pH, electric or magnetic fields. Entire systems made from materials that react to external inputs by changing their characteristics and functions, or that in turn provide input to other parts of the system making it adaptive, result in something that closely resembles a living organism, which can perform functions without further intervention, adapting to external conditions and performing the desired operations. In addition to Smart Materials, there are also a number of new materials that, although not "smart", have revolutionary performance and characteristics compared to canonical materials and can enable great innovations in many fields.

The Smart Materials that have been covered in the Report are:
*   **Piezoelectric materials,** i.e. various types of ceramics, polymers, crystals and composites that can generate electrical voltage when subjected to external pressure;
*   **Shape Memory Alloys (SMA) or Polymers (Shape Memory Polymers or SMP),** which are able to deform temporarily and then return to their original shape thanks to certain external stimuli, for example due to a change in temperature;
*   **Self-Healing Materials,** artificial or synthetic substances that have the ability to repair their own damage without external diagnosis of the problem or human intervention;
*   **Electroactive polymers (EAP)**, materials that show a change in size or shape when stimulated by an electric field;
*   **Chromogenic materials,** substances capable of modifying their optical characteristics in response to external stimuli.

As for the **new materials,** an important focus was given to **Graphene, the first two-dimensional material ever discovered**, as well as one of the strongest materials in the known universe. In addition to its extraordinary resistance, Graphene is also flexible, transparent, highly conductive and impermeable to almost all gases and liquids. For the discovery of this material, Andre Geim and Konstantin Novoselov were awarded the Nobel Prize for Physics in 2010. Moreover, Graphene is the protagonist of the biggest European research activity ever carried out, the "Graphene Flagship", which, launched in October 2013, has the task of bringing Graphene from research centers to the markets in 10 years, with a budget of €1 billion. Other types of new materials covered in the Report include cellulose nanofiber, aerogel, transparent aluminum, ecoallene, fullerene (carbon nanotubes), and the ultralight metallic microlattices.

9   Frontier technologies: innovative ideas for a sustainable future

Every year the InnoTech Community of The European House - Ambrosetti maps and analyses some of the **most interesting innovative ideas and the most successful business cases at international level,** with two main goals:
- to **understand the main innovation trends** in the world and their dynamics;
- to **transfer international best practices to the Italian innovation ecosystem** and, in particular, to the companies that are part of the InnoTech Community with an attention on the growth of the country.

The Report presents twenty of the most interesting and potential innovative ideas gathered by the InnoTech Community Observatory during its activities in 2019. This collection of ideas provides some examples of real-world applications of the technological trends discussed in the Report, which can impact the lives of people and businesses alike, with an eye to sustainability and Planet Earth's well-being. The mapped ideas include: a bio-computer so small it fits into a cell, the ink extracted from pollution, a sustainable plastic made with greenhouse gases and the edible water bubble.

The Italian ecosystem of innovation

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Innovation is a driver of growth and competitiveness for every country, especially in the current globalized economic-productive context, which evolves rapidly and is pervaded by technology. Despite this awareness, **Italy still invests less in research than the other main European countries:** in 2017 Italy invested €23.3 billion in R&D, compared to Germany's €99 billion, France's €50.1 billion and the United Kingdom's €38.9 billion. **(Figure 6)**
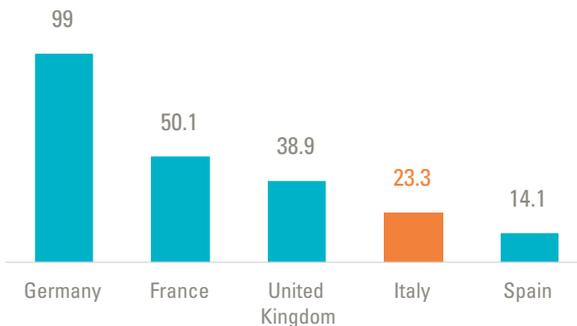
Figure 6 |
Investments in R&D in the Top-5 European countries (billion Euros), 2017. Source: The European House - Ambrosetti, based on Eurostat data, 2019

99	50.1	38.9	23.3	14.1
Germany	France	United Kingdom	Italy	Spain

It is therefore increasingly important that national institutions take action to generate critical mass, channeling available resources on effective measures with a high potential. Furthermore, these actions have to focus on growing the private sector's relevance in this scenario, since its contribution is still too little, while its potential is far greater.

Over the past year, both the Italian Institutions and the private sector have made strides in recognizing the great importance of innovation and technology for the growth of the country and its economy. Among the **main actions taken in the past year** are:

- The creation of the **"National Innovation Fund"** (Fondo Nazionale Innovazione) with a budget of €1 billion, which aims to stimulate growth and innovation in Italy, promoting international competitiveness and making the country ready for the development of new technologies and the growth of innovative businesses. In short, the goal is to transform Italy into a "Smart Nation".

- The setting up of the **"Technological Development Fund"** (Fondo Sviluppo Tecnologico) with a budget of €45 million, for interventions in the fields of Artificial Intelligence, Blockchain, and Internet of Things.
- The creation of a €75 million fund to recruit **"Innovation Managers"**, professionals who can support SMEs wishing to invest in innovation and digital technologies.
- The approval of the **"5G Emerging Technologies Support Program"** with a budget of €45 million, with the aim of carrying out experiments, applied research and Technology Transfer projects, related to emerging technologies, such as Blockchain, Artificial Intelligence and Internet of Things, connected to the development of 5G networks.

11   Guidelines for the growth of the Italian ecosystem of innovation

Since its inception in 2011, The InnoTech Community of The European House - Ambrosetti has set itself the goal of giving a real contribution to Italy's growth by suggesting at **policy-makers guidelines aimed at increasing the level of attractiveness and international competitiveness of the national ecosystem of innovation.**

Despite the important measures developed in recent years in favor of research, innovation and technology, great efforts are still needed to compete with the major economic powers, in Europe and globally.

As part of last year's work, these **five guidelines** have been identified as strategic for the growth and competitiveness of the national innovation ecosystem:

1. Set up a **research group on 6G** networks.
2. Carry out a pilot project for the experimentation of the **first "Smart & Circular Region" in Italy.**
3. Promote education programs to develop the **technological skills of the future.**
4. Include **Artificial Intelligence** among the responsibilities of the national **Chief Technology Officer.**
5. Establish the **Italian observatory for the study of co-benefits.**

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