



Case study on CEA - Alternative Energies and Atomic Energy Commission, France

Contribution to the OECD TIP Knowledge Transfer and Policies project

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Energy Commission, France: Contribution to the OECD
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Introduction

The Alternative Energies and Atomic Energy Commission or CEA (French: *Commissariat à l'énergie atomique et aux énergies alternatives*), is a French government-funded research organisation, created in 1945.

For over 70 years, CEA has led, on behalf of the State, a number of research programs to increase scientific knowledge and contribute to innovation and technology transfer in areas such as:

- low carbon energies (nuclear and renewable energies),
- defence and security,
- technological research for industry,
- fundamental research in the physical sciences and life sciences.

Its yearly budget amounts to approximately 4.3 billion euros and its permanent staff numbers about 16,000. Technicians, engineers, researchers and staff are working in nine centers spread throughout France.

CEA maintains a cross-disciplinary culture of engineers and researchers, building on the synergies between fundamental and technological research. All the research is conducted by four operational divisions.

- **The division of nuclear energy (DEN)** : CEA is behind the development of the French nuclear industry: together with EDF, they designed the first generation of reactors in the French fleet and most of the industrial-scale processes currently used in Areva's nuclear fuel cycle plants. CEA provides public authorities and industry with the expertise and innovation needed to develop improved nuclear power generation systems. It is responsible for research and innovation programs in two key areas: supporting the French nuclear industry and developing the future nuclear systems called *Generation IV*. CEA is also continuing to investigate thermonuclear fusion, in particular via the international project called ITER which involves building the first prototype designed to demonstrate the scientific and technical feasibility of this source of energy. Thanks to its long-standing activities in the nuclear field, CEA has built up expertise in nuclear radiobiology and toxicology.
- **The division of military applications (DAM)** : DAM is key player in developing France's nuclear deterrent. It builds the nuclear weapons of the French military and designs the power plants for the nuclear submarines of the French Navy. Since the French nuclear testing program ended in 1996, the Simulation Program became the only way to guarantee the performance and safety of nuclear weapons. Ever since, computing resources (TERA), and high power laser experimentation resources (the LIL and the LMJ) have become the key elements of this program.
- **The division of technological research (DRT)** : DRT is based on a strong scientific, industrial and academic environment. It is focused on cutting-edge technological research and development in the field of energy, information and health care technology. It provides an active role in transferring knowledge and

research ideas into industry. DRT includes three technological labs: The **Leti lab** works mainly on micro/nano technologies and is specialised in microsystems, biotech, photonics and nanoelectronics. The **Liten lab** works mainly on innovative technologies related to energy and nanomaterials. It specialises in building solar systems, carbon-free transport, biomass-hydrogen, nanomaterials and other nanotechnologies. The **List lab** works mainly on systems and software-intensive technology and is specialised in embedded systems, sensors, big data and advanced manufacturing. DRT also operates **CEA Tech branch offices** in a number of regions in France.

- **the division of Fundamental Research (DRF)** : Through fundamental research in biology, physics and chemistry, the basic research division, DRF, strongly contributes to all of CEA’s research programs in many fields, from renewable and nuclear energy, to health, lasers, and micro and nanotechnology. It contributes to the development of very large research infrastructures, high performance computing, and also takes part in theoretical physics investigation at the highest level internationally.

When appropriate, the results of research conducted at CEA form the basis of patent applications. In 2017, 762 priority patents were filed, adding to a portfolio of nearly 6,300 patent families in force, and confirming CEA as a leading research organisation for patent submissions to the French National Institute of Intellectual Property (INPI).

CEA has also achieved prominence in the Clarivate (ex-Reuters) rankings. For 7 years in a row, CEA has appeared on the “*Top 100 Global Innovators*” list that identifies “the world’s most effective innovators”, and it was in second place in the 2016 “*Top 25 Global Innovators—Government*” list of “publicly funded institutions doing the most to advance science and technology”.

CEA’s large worldwide patent portfolio is mainly exploited via technology transfer activities with industry, leading to over 600 industrial partnerships in 2017.

Patents also play a driving role in the creation of new innovative businesses. Another 9 new start-ups were created in 2017, consolidating a longstanding trend that has seen 204 companies created since the beginning of this activity. To support the growth of these fledgling companies, CEA has also engaged in seed funding, an activity that is coordinated by two subsidiaries: CEA *Investissement*, launched in 1999, and *Supernova Invest*, which was created in 2017.

Also of note is that CEA’s technological transfer activities are supported by a strategic marketing group, including a bibliometric/patent research service, whose tried-and-tested expertise helps the labs to optimise their “commercialisation” of scientific research.

¹ TOP 100 highlights the most successful organisations in the world that are active in innovation through research and development, protection of their intellectual property and achievement of commercial success.

² TOP 25: CEA ranks second among the TOP 25 in part because its researchers apply for and receive significantly more patents than most government organisations - an indication that its research has strong potential for commercial value. Those patents are also frequently cited by outside researchers, showing that CEA has a big impact on R&D efforts at other organizations.

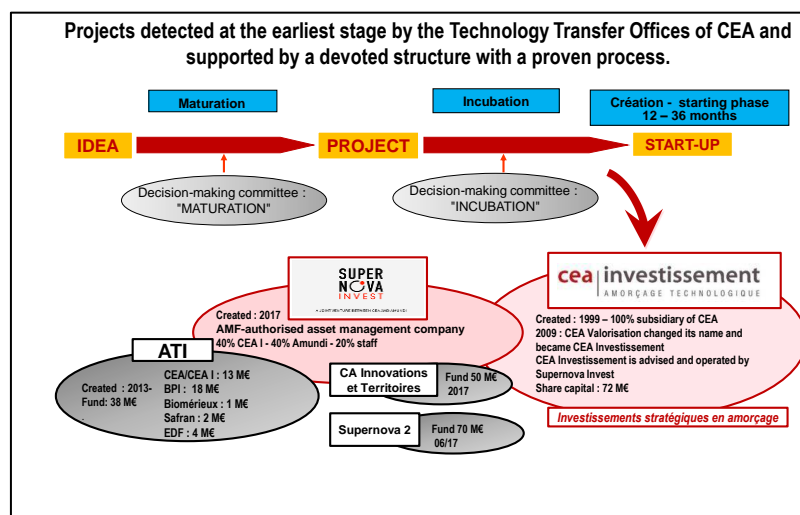
1. Strategy to support spin-offs

New businesses, especially in sectors that can create skilled jobs and generate products or services with a global market, are obviously of considerable interest to help develop and renew the economic fabric of the country. Public authorities consider them both as a way to provide direct and indirect employment, as well as a driver for the development of modern society.

Historically, CEA has supported the creation of start-ups that are involved in its areas of interest. Indeed, this effort is quite naturally part of CEA's mission to meet the needs of the country's social and economic development. By this way, it contributes more effectively to job creation on the national territory.

CEA's has acquired a significant experience in this activity, developing a set of key competences and a framework to develop start-ups that has proven to be successful (See below the figure).

Figure 1. Steps in creation and development of start-ups at CEA



It should also be stressed that the success and the expansion of technology transfer activities are closely related to different factors, such as management's constant commitment to stimulating this kind of activity, the creation of a dedicated support organisation, and careful and effective monitoring of results through appropriate reporting methods.

Fostering an innovation-friendly environment, where researchers projects from their earlier stage of development to business development are supported at different steps with a large range of tools, is key. However, one of the essential aspects of CEA's approach lies also in its ability to inspire teams to generate projects: no project*, no business we could say!

*projects can occur at various stages of the innovation process, in early stages a project is an action by teams to validate a technical concept, while in later stages projects, especially business projects, intend to reach the market.

2. From idea to project: detection and maturation of innovative projects

Detection and maturation of innovative projects within laboratories, in order to optimise the transition of these projects towards the incubation phase, are absolutely key.

The objective of the maturation stage is to reach a stage of technological maturity, which is part of a tech transfer strategy and then leads to the search for industrial partners or the creation of a company. Researchers during this stage will develop their ideas and will have to provide a *proof of concept (POC)*.

This step often requires additional funding which can range from a few thousand euros to several millions but also skills on technical aspects, intellectual property, market, tech transfer strategy....

The whole process, from the detection of an invention to its transfer in the economic world, can take several months, even several years. This time depends in particular on the level of maturity of a technology (TRL), the target markets and the means implemented by the technology operators.

The detection step is conducted within each division according to its own processes, as well as maturation activities that are not pooled at CEA. To arouse and to identify such projects, each division has implemented different tools such as internal calls for proposals with dedicated funding.

As an example, DRT has launched a tool to support projects at the detection and maturation stage called “*Challenge First Step*”. This new type of program is based on an internal ideas competition, whose objective is to help candidates who want to create a start-up. Each year, all the participants will be trained and will work together as a team. The “*Challenge First Step*” includes some form of competition, since only the most promising projects (approx. 1/3) will receive funding and specific support. This tool is created in addition to what already exists and is currently only proposed at the Grenoble Center. The proposed scheme shows promising results: 16 start-ups have been created from projects that have entered this scheme.

77 projects have been proposed between 2012 and 2017. 47 holders have taken part to the program and finally 31 have been funded for a total amount of approximately EUR 3.6 million.

However, internal financial resources devoted to these programs by divisions remain constrained - from a few hundred thousand euros to just over one million euros per year.

Funding is therefore the result of a strategic choice by each Division to mobilise part of its budget to develop the maturation of certain projects, some of which will be oriented towards business creation.

Also, it has to be stressed that financial means are limited and only meet a part of the needs.

In the rest of the document, we will present measures that focus more on the incubation step.

3. From researchers to entrepreneurs

Each year, a few researchers (5 to 10 /y) make the leap and leave their laboratory to start their own business. A choice that remains marginal, motivated most often by the desire to promote promising research results that industrialists do not dare to exploit. To help these future entrepreneurs at each stage of the maturation of their project, CEA has put in place human and financial support. At the end: original human adventures, virtuous partnership agreements, products that find their place and utility in the market and lead to job creation.

Why choose to start a business when working at CEA? What motivates such a decision? Is it the desire to stop conducting research anymore?

In fact, different stories show us that business creation depends more often on the desire to value a promising discovery from a laboratory. In practice, when a result seems to have applications, laboratories opt, in 90% of cases, for a technology transfer to an existing company. Protected by one or more patents and with an appropriate license agreement, the industrial partner will ensure the development and marketing steps of future products.

When manufacturers seem cautious, when the discovery represents a technological breakthrough with a significant risk, to start a business can be a strategy for laboratories - for CEA - and for researchers who can choose then to carry the project, from development to market.

In practice, every business creation is a unique adventure, the result of the motivation and the personality of the ones who make this choice.

At the moment business creation is considered, researchers are invited to contact the "*Start-up Unit*" and the *start-up contact* in their division. When the idea has taken shape, when it seems to answer to a real need of the market, holders and projects evolve according to a process with several steps - maturation, incubation - during which they receive financial aids and different supports : legal, technical, commercial ...

When the company is on the launching pad: entrepreneurs build their team, set partnership agreements with their home laboratory, meet their future customers, prepare financing plan and company statutes... and gradually take their autonomy. A new life begins, even if CEA is never far away.

3.1. Specific support for permanent staff

CEA start-ups may access to different funding, ranging from public subsidies granted by various local authorities and the State, to private funds provided by investment companies and individual investors.

In terms of financing, the CEA supports employees who want to start their own business or acquire an existing company by two ways:

- directly, during the incubation phase, by covering the wages of researchers (3 X 6 months max / person) and by granting "*loans on trust*" (unsecured, interest-free loans) if needed (up to 40 K€ max), and also financing expenses related to the project (market studies, technical developments...),
- indirectly, when it comes to fundraising campaigns, with *CEA Investissement* and *Supernova Invest*, two companies that provide young start-ups with seed capital (See § 4.2 next).

If entrepreneurs want to return to CEA as an employee, they may do so up to a period of 4 years maximum.

The feedback shows that the cases are varied : some - but it is a minority - after being greatly involved in the creation of their company want to return to work in laboratories while others continue their career as business leaders and leave CEA permanently.

No matter how well employees plan and prepare, starting a business is a gamble. However, the process is not without risks. Starting your own business means confronting the possibility of failure. Understanding the risks inherent in starting a business is the first and most important step in overcoming those risks and trying to succeed against the odds.

3.2. Financial aspects

Employees shares as investors

CEA employees may participate in share capital up to a maximum of 15% (total shares of CEA employees) in start-up companies and can't have a management function in the start-up at the same time. In this case, they are not allowed to participate in the elaboration or the signing of contracts or agreements between the company and CEA and more generally must not interfere, even indirectly (by proxy), in the relations of CEA with the company. They have to inform their manager when they hold shares in a company. Indeed, such situation may create conflicts of interest that have to be prevent. This is also the reason why employees are not allowed to work part time for CEA and another company linked with CEA activities at the same time.

Employee Founders' shares

In the case of an employee creating a start-up, once the employee's status has changed (starting from the date of entry into force of the business start-up leave), the CEA restrictions are lifted. As founding members, they shall subscribe an important part of the shares capital and / or may have a management function in the company.

CEA Founders' shares

CEA, through its subsidiary *CEA Investissement*, has the right to be co-founder of start-up, up to 15% of the share capital. This is made possible in recognition of all of the resources CEA makes available and that are used by the project. This rate may be higher - depending on the duration and incubation measures put in place, or lower, in appropriate circumstances.

A unilateral commitment is signed by the employee-founder (s) : he promises to subscribe for shares to the benefit of *CEA Investissement*. This unilateral commitment is signed at the same time of the incubation agreement.

In the event of sale of founders' shares held by *CEA Investissement* on behalf of CEA, laboratories that were involved in the incubation stage will benefit from a return based on the amount of the capital gain on the sale of these shares, after agreement between CEA and *CEA Investissement*.

This founders' shares mechanism, put in place in 2008, plays a significant role in terms of team motivation.

1.1 - Start-ups governance

CEA is not directly involved in start-ups governance. *CEA Investissement*, as co-founder and shareholder, and *Supernova Invest* may play a significant role in start-ups governance, and this, especially if they also act as investors (See 4.2 next).

4. From project to start-ups: CEA's framework to develop start-ups

CEA's framework to develop its start-ups represents a comprehensive and staged approach:

- Some actions are carried out before the company is founded,
- and some are implemented after company formation that can be considered as a transitional point, allowing CEA's project leader to change their status (from a CEA employee to become a start-up employee).

CEA has a dedicated entrepreneurial unit - la cellule "*Essaimage et création d'entreprise*" – comprising 5 people, that is tasked with assisting employees who would like to start a business or acquire an existing business. It deals with the requests of employees of the whole organisation, whatever the division they come from.

This "*Start-up Unit*" supports employees through various phases of project development by calling on internal or external expertise when needed. Indeed, public incubators or other support organisations can also be called on to work in partnership.

The ultimate goal of the whole process is to set up innovative companies based on CEA technologies or know-how.

4.1. Before company formation: valuing entrepreneurship and fostering the emergence, development of viable enterprises

Fostering entrepreneurship

The fear of failure is certainly a major obstacle to starting a business, or more precisely, fear of the conditions that are subsequently imposed on an entrepreneur who has suffered a first failure.

To address this fear and to better inform employees, various actions are carried out within the organisation to raise awareness and encourage entrepreneurship.

Different initiatives are proposed ranging from training days at the center with very useful information and tips particularly appreciated by the participants, to more targeted events that focus on specific points of the entrepreneurial path, interactive exchanges with other founders of start-ups or actors accompanying the business creation projects. CEA recognises that, in many cases, the idea of starting a business comes first and foremost from the experiences of people who are relatively close to the creator. It's their success that gives others the urge to try and start the entrepreneurial process.

Identify and select the promising projects

CEA's business creation process starts with a step of identification and selection of promising projects.

This task falls within the remit of the "*Decision-making committee : "INCUBATION"* (We will call it "*start-up committee*" next in the text) This committee, led by the "*Start-up Unit*", examines the business creation projects proposed by the Operational Departments on a regular basis, at various stages of their progress.

Presentation (by the creator) in front of this committee also gives visibility to the projects, giving them an internally recognised status. The committee is composed of several permanent members with varied and complementary profiles (IP, human resources, marketing, and investment). It includes people of the "*Start-up Unit*", representatives of the laboratory / department / institute carrying the project but also external personalities recognised by the CEA for their expertise in this field.

Through consensus, the committee will decide, if the project leader(s) can enter the business incubation program or not. Indeed, this program gives them access to various accompanying measures on a personal basis but also to the project itself.

The act whereby a start-up project is accepted into the incubation program is important because it commits CEA to completely release the project holders from their professional activities to enable them to devote themselves to their start-up project. However, this decision requires the prior approval of the Operational Department from which the project came, because it bears the financial burden of this decision.

A program opened to complementary external expertise

Even if we consider that CEA's employees are inventive, not all of them have the skills or desire required to be an entrepreneur. This is why, for several years, CEA has also supported start-ups that value its technologies but whose founders are not from its ranks and come mostly from industry.

In this case, the business incubation program for start-up projects supported by external holders is similar to those provided to CEA's employees, with some adjustments due to the non-CEA salaried status of the holder.

Selection criteria

Several criteria are taken into account to decide whether a project should be selected or not for the business incubation program. Among those, we can quote the intelligibility of the value proposition (market identification and differentiation), the market access strategy and the business model, the technological feasibility, the strength of the intellectual property, and the financing capabilities... The motivations of the project holder and the strength of the team are also important points of attention.

Indeed, the creation of a technological company is very rarely the result of a single person, but almost systematically the work of a team with complementary skills. It is then a question of associating the technological mastery of CEA's collaborators with proven professional practices of marketing or management, with a good knowledge of the business network, for which the competences are often found externally.

It is also to underline that the strength of the management team plays a key role in investors' and lenders' decision to fund a venture.

Tailor made advices and support

It should be noted that the "*start-up committee*" will also decide whether or not to extend the participation of a project holder to the business incubation program. Incubation periods

are set for a period of 6 months, renewable a maximum of 2 times, for a total duration of 18 months (See § 4.1).

At the end of each project review, the "*start-up committee*" makes specific recommendations to the project holder. Objectives that will be discussed at the next project review, can also be set.

In addition, an incubation agreement setting out the operating rules of the project during the incubation period is signed between the project holder and CEA. The contractually agreed terms are presented at a meeting "*kick off incubation*" scheduled within a short time after the decision date of incubation. The operational role to follow the project on a regular basis is ensured by the Operational Division, the relevant institute within CEA that is hosting the project.

The "*start-up committee*" may, in some cases, review projects during the technological maturation stage, so that the project team can benefit from its opinion. The type of project, for which an opinion is requested from the committee, is usually led by a project holder planning to be a future entrepreneur.

In the event that the project has not reached sufficient technological maturity to determine the appropriate means of technology transfer (through an existing industrial or via start-up), the committee can take a position on the relevance of a technology transfer by start-up and make a number of recommendations.

The set of measures proposed during the incubation period are aimed at allowing the project holders to devote themselves to their project and especially to their customers, and to focus on their core business without being distracted.

Skills development and entrepreneur training

If strength of character is an essential element to succeeding in business creation, we can say that the job of entrepreneur is also something that can be taught. Incubation can then be thought of as a process, formal and informal, of learning and assistance, which allows the project holder to acquire the skills and / or resources that are lacking and are necessary for the success of his project.

Throughout the incubation period, the project holder will be supported by the teams of the "*Start-up Unit*" to build and consolidate his project, but also to be part of the various networks that will be essential to the development of his future company. More particularly, one should mention:

- **Networks for advice and training**, in areas that are not always mastered by the project holder (management, legal issues: company statutes, protection of intellectual property, partnership contracts ...). Various training programs or programs financed by CEA during the incubation period can be offered to project holders in partnership with local incubators or business schools (e.g. HEC, EM Lyon ...).
- **Scientific and technological networks** can help respond to difficulties encountered during the development of the project. In high-tech fields, the technological dimension, the construction of prototypes and / or test facilities is often decisive and the links that may remain between the project holder and his laboratory of origin are extremely important.

- **Financial networks** (Business Angel, venture capital, local capital, banks, etc.) for the financial arrangement of the project. In this respect, CEA has set up specific tools for financial support presented below (cf. *CEA Investissement* and *Supernova Invest*).
- It is important to note that for all business creation whose activity is based wholly or partly on the exploitation of CEA's scientific or technological knowledge, CEA has a right to share in the capital as a co-founder of the company up to 15% reflecting all the resources made available by CEA for the benefit of the employee carrying out the project. *CEA Investissement* is the company that effectively owns the shares of founder on behalf of its parent company (cf. § 4.2).
- **Industrial networks** are important as the young company will need partners or subcontractors, suppliers and first customers.

If the internal support is carried out by the "*Start-up Unit*" and a network of correspondents located on each Center, external entities provide the "tertiary and economic" support for projects.

Market need and Time to market

During the incubation period, the project holder will evaluate the reliability and validity of his project and his results in order to minimise the risk of failures. He will explore in a more refined way the opportunities on the market to exploit and refine its business model.

To help the project holder in this regard, since the 1990s, CEA has developed a capability to identify the markets, applications and actors who could be implicated by its innovative technologies.

This expertise is supported by the "*Marketing Unit*" (*Service Bibliométrie-Etudes-Marketing, SBEM*), comprising some 20 people.

The action of this unit focuses on two main missions: to support technology transfer from laboratories to industrial partners or via the creation of start-ups and also to provide elements of strategic analysis to help guide CEA decision making.

The *Marketing Unit's* contribution is perfectly integrated into the business creation process and project holders use its services extensively to assess the market potential of targeted applications, to better understand the time to market or the validity of the value proposition proposed by the start-up project. However, it is true that market behaviour remains difficult to anticipate and a certain number of innovations may not find an outlet because the market did not grow at the expected speed. In this respect, it must be recognised that the difficulty of apprehending and then positioning oneself on the market remains one of the main causes of failure for young companies.

Deep tech start-ups

Many start-ups today refer to themselves as "technology startups" as the term "technology" has started to take on a broad sense. Some of these start-ups use technology that is commonly available; while others may build their business around unique, differentiated, often protected or hard to reproduce, technological or scientific advances. These latter start-ups, distinguished by the term "*deep tech start-up*", are certainly the carriers of the breakthrough innovations of tomorrow.

Unlike traditional start-ups, time-to-market for deep tech start-ups is often long, particularly because an R&D effort must be continued and consolidated over time to

transform the technology developed within a laboratory into a product or a functional service.

It is not uncommon to have to wait more than ten years before reaching the stage of commercialisation and to generate a return on investment. Although the associated risks are significant, these start-ups nevertheless open unprecedented perspectives which, if successful, can largely justify the efforts. However, deep tech start-ups face a real difficulty in finding funding to ensure their development - which may require several million euros before generating a return. Their high capital requirements, coupled with high risk, can make investors more cautious.

Companies from CEA's laboratories are almost exclusively part of the "deep tech startups" category (more than 75%). Given the elements explained above, it is clear that the proximity between the business start-up project (and later on the startup company) and the original laboratory is a very important factor for the success of the project.

Strong links with the laboratories where start-ups come from... but not without risks

Almost all start-ups continue their R&D efforts in the framework of collaboration agreements with CEA and are often hosted on the sites where they were born, at least in their early years. These young research partners, however, do not have a proven financial strength and the collaborations set up therefore undeniably carry some financial risk that the research units of the organisation must bear.

Indeed, in some cases, young companies may have difficulty meeting their financial commitments while raising new funds: it is then necessary to manage a delicate period, with a cessation of payments that could result in bankruptcy.

IP models and start-ups

Knowledge and intellectual property are going to be on the front line of the economic battlefield in the future.

Within this context, CEA has implemented a vigorous policy in recent years to encourage researchers to protect their results with intellectual property.

As a reminder, in 2017, 762 priority patents were filed, adding to a portfolio of nearly 6,300 patent families in force.

To achieve this, CEA has recommended its divisions consolidating expertise in matters relating to intellectual property, and creating positions for specialists in this area (like corporate patent engineers, Intellectual Property and Legal experts...) in most of the CEA's Operational Divisions, to liaise between the laboratories and the economic world.

A training program was also set up to increase young PhD students' awareness of how important it is to protect intellectual property by filing patent applications. Also, the incentive bonus scheme linked to operating income generated by patents has been back in operation for over ten years.

Lastly, it should be noted that start-ups that value CEA technology with a portfolio of patents or know-how will be eligible for a license. The conditions for granting this license take into account the specificities of each company: scope, exclusivity on products and / or markets, financial terms... They are negotiated with the managers responsible for the transfer of technology of each Operational Division.

CEA's model focuses on innovation with industrial companies requires secure intellectual property. Indeed, it is the foundation of research partnership that CEA offers to industry,

by addressing both large groups, SMEs and start-ups. This model is based above all on scientific research at the highest level, adaptable to the needs of industry, led by teams recognised for their excellence and platforms that are successful and unique in the world.

The innovation process has become more competitive, more focused and more globalised and promotes the creation of technology-based businesses and industries. As a result, companies also need more and more reliable IP assets in order to compete internationally. IP has thus become an important asset that industrial partners must master in order to "secure" a position in the geographical areas where they want to sell their products. Depending on the sector (size of the market, rate of renewal of products), the filing of a large number of patents becomes more or less strategic. For example, it is particularly essential in the field of microelectronics and generally information and communication technology (ICT), but also new energy technologies or health.

For deep tech start-ups, IP is an essential part of their development strategy. It is also one of the foundations of venture capital investments: indeed without valuable IP, little investment would be made in new or developing companies in some sectors.

4.2. After company formation

The search for financing remains a crucial step both at the start of the business of a company but also afterwards to finance its growth. The leaders of start-ups spend a lot of their time on this aspect and the key question is getting the right level of investment at the right time.

To support its start-ups during the creation and start-up phases, CEA is equipped with various financing vehicles orchestrated by the following companies: *CEA Investissement* and *Supernova Invest*.

CEA Investissement was established in 1999. It is a wholly-owned subsidiary of CEA, enabling direct investments into start-ups, with appropriate in-house governance schemes an "ever green" investment fund model. *CEA Investissement* is also a holding company for both equity participations in start-ups and additional investments vehicles shared with external partners. It intervenes directly in the capital of start-ups through the acquisition of stakes in innovative companies presenting major challenges for the institution's missions. It aims to support these companies at each stage of their growth. By the end of 2017 the Company's share capital was 72 M€.

In 2017, a Joint Venture Company was formed between *CEA Investissement* and the leading asset management Company *Amundi*, through its subsidiary *Amundi Private Equity Fund*, to form a unique independent Investment VC Fund, *Supernova Invest*, approved by the AMF (Autorité des Marchés Financiers), the French financial market authority.

Supernova Invest is a management company with a very solid expertise in deep tech innovation. It is co-owned by CEA (40%), *Amundi Private Equity Funds* (40%) and by the management team (20%).

Supernova benefits from the experience of the former *CEA Investissement* team which was transferred to the company when it was created and is now employed in this new company. It also benefits from a preferred access to CEA's ecosystem, knowhow and infrastructures.

The company has a workforce of 8 people and manages or advises 5 funds for a total of 250 M€.

Since 1999, *CEA Investissement* and *Supernova Invest* have financed and supported more than 100 start-ups in their fields of expertise: life sciences, energy & environment, industry,

microelectronics and digital. A large number of these companies carry technologies from CEA laboratories.

5. Results achieved so far

Since the 1970's and until the end of 2017, CEA's start-up development program has led to the emergence of 204 companies that rely on CEA technologies.

However, the data show that stronger activity has taken place over the last 10 years, with 103 companies created over the period 2008 and 2017.

In addition, the data show that there are also strong site dynamics. Indeed, although CEA's activities are split between 9 different research centers in France, two of these centers, in Grenoble and Saclay, appear historically as the more likely sites to give birth to spin-offs. The data on the period 2008 and 2017 confirm the capacity of these centers to generate innovations which can be brought on the market by the creation of new businesses.

Thus, 61 start-ups created between 2008 and 2017 were developed by the Center in Grenoble, which represents nearly 60% of the start-ups created over the period. 32 were developed by the Saclay Center, i.e. 31% of the creations over the period and 10 were developed by the other Centers of the CEA (mainly Cadarache, Marcoule or DAM Center: Bruyère le Châtel).

In addition, it is also important to take into account the importance of local ecosystems. The region around Grenoble represents an ecosystem that many would not hesitate to qualify as exceptional because of its proven know-how in terms of technology transfer and more specifically through the channel of business creation. For more than a century, cooperation between actors in higher education and research, industry and local authorities has developed and become firmly rooted in practices. They have helped to support value creation from ideas and discoveries to industrialisation.

This tripartite synergy is based on a high concentration of public and private actors involved in scientific research, a set of organisations (national and international), schools and universities, carrying an intense activity of technological dissemination. The presence of a dense industrial fabric that integrates innovative companies and whose existence and performance are largely due to their ability to exploit the results of local research is also extremely important, as is the development of a network of local actors supporting technology transfer activities. Finally, the continuous and regular support of local authorities to encourage and develop these activities undeniably contributes to strengthening this ecosystem.

In addition, it should be noted that to support young companies in their start-up phase, CEA with the support of its partners, has initiated various experiments that led, for example, to the creation of *MINATEC micro and nanotechnology innovation campus* on the CEA Grenoble site.

This campus makes it possible to bring together in a single place the triple helix of research - education and industry. For this purpose, buildings have been built on the CEA Grenoble site to allow the hosting of start-ups - but also more widely industrial partners involved in collaborations with Minatec partners - with a service environment covering all the different needs of technology transfer to industry.

The Saclay site is also known for the creation of a major ecosystem of innovation in France. Actors in research, industry and education work together to coordinate actions and create an environment conducive to the birth of new innovative companies. The dynamics in terms of start-ups creation is already significant.

The more qualitative analysis of the results shows that the CEA's business creation scheme has made it possible to generate companies that have today become industrial champions in various fields but always in synergy with CEA's activities. If we consider the creations prior to 2007, we can cite as an example in microelectronics and systems: *Soitec*, *Sofradir-Ulis Group*, *Tronics Microsystems*, *Movéa*, *M2M* or *Haption*, in biotechnology, *Bertin Pharma* or *Protéine expert*.

If the technology on which these companies started their business comes from the CEA laboratories, it is clear that lasting and trusting relationships have been established over time.

If we consider the companies created over the last 10 years (2008 to 2017 – 103 companies), it appears that microelectronics, software and systems, but also, biotechnologies and medical devices or even new energy technologies and materials are the areas that generate the most initiatives.

As such, we can mention some projects to illustrate the point:

- Software & systems: *Extende*, *Arcure*, *Kalray*, *ISKN*
- Microelectronics: *Aledia*, *Ethera*, *Isorg*, *Exagan*
- New Energy Technologies: *Symbiofcell*, *Sylfen*,
- Biotechnologies and medical devices: *Pixium Vision*, *Fluoptics*, *Cytoo*, *Diabeloop*, *Theranexus*
- Materials: *Nanomakers*, *Nawatechnologies*, *Extracthive*, *APIX* ...

The analysis of the evolution of the start-up companies, created between 2008 and 2017, shows that 13 companies of the 103 have stopped their activity, representing about 13% of the total.

This failure rate, which can be considered as very low, also reflects the implementation of a scheme which remains very selective in terms of the projects it chooses.

In the event of a cessation of activity, it appears that the companies ceased their activity either early in the process or after a few years. A common point to all these failures: they did not find the market that was necessary for their development and the investors did not continue to invest.

Finally, it should be noted that 3 out of 103 companies were acquired by third parties. The others continue their development and CEA is naturally present at their side to support them in their actions.

If we look at the ability of these companies to attract investors, it appears that of the 87 companies that continue their business, almost half have raised financing. For some, it is already several rounds of financing that have been made, sometimes even through an IPO. The amounts raised range from 1 to several tens of millions of euros, depending on the project carried by the company and its needs.

To complete this point, it should be noted that start-ups created during the 2011-2017 period have raised 189 M€ of funds over the 5 past years (2012-2017).

At the end of 2016, the 87 active companies created between 2008 and 2017 have created nearly 1000 direct jobs and generate a turnover of around 50 M€.

15 companies had more than 20 employees and 16 had sales of more than 1 M€.

6. Interactions within the broader national context

The support of public incubators is very complementary to the "*technological incubation*", carried out internally by the laboratories, and to the input of internal actors coordinated by the "*Start-up Unit*".

Indeed, tools developed by CEA or with the strong support of CEA are very complementary to national public and private ecosystems, especially when it comes to financing, as they often play the role of a catalyst and "integrator" for other investors, closing the information gap between financially driven investors and technological or industrial experts.

It should also be pointed out that French legislation provides various aids to encourage companies to support and continue their research efforts. The Research Tax Credit (*Crédit impôt Recherche - CIR*) is a generic measure of support for business R & D activities. Research collaborations benefit from this favorable taxation and for research conducted with public research organisations like CEA there is a further contribution. This scheme is extremely important for young companies with high needs for technological research.

We have seen before that CEA makes great efforts to fund as much as possible its projects at the maturation stage which may require important funding. But despite all the tools that have been implemented, we have underlined that internal resources could not meet all the needs: that is the reason why support from public funding at the maturation stage is so important.

While it is conceivable that some projects may meet the criteria for standard calls for projects (such as collaborative projects, FUI), specific funding is more appropriate.

To this end, the *French Tech*³ and *Bpifrance* have for example set up grants to support the creation of innovative companies that require a phase of maturation and technical and / or economic validation (*French Tech Grants* up to 45 K €).

In addition, the State has also funded a nationwide series of SATTs⁴. A SATT must, in principle, provide technology detection and maturation services developed by its (associate) members, in exchange for remuneration based on royalties subsequently

³ French Tech : The Government created the French Tech Initiative in late 2013. Objective: to improve the legibility and coherence of public actions in favor of startups. It does not create a new organisation or new public tool, but it is carried by a small team, Mission French Tech, which works closely with different departments and state services or other players in the ecosystem. Funding from the French Tech Initiative dedicated to accelerators (200 M€) and international attractiveness (15 M€) is part of the "Investment for the Future" program (PIA).

⁴ SATT : Technology Transfer Accelerator Offices Technology Transfer Accelerator Offices or SATT are French private TTOs, shared between several public research organisations, created to develop and commercialise research results to be transformed into innovative products. They are part of the measures implemented for the "Investment for the Future" program (PIA), whose ambition is to meet the innovation gap. 14 SATTs have been created, as the cooperation between the public research and the private sector has been identified as key for economic competitiveness.

obtained through licensing to industrial partners. Generally, the partners undertake to grant to the SATT an exclusive license to the results from a maturation project (in all the technical fields and for the duration of the IP) with a sublicensing right concerning the stated intellectual property rights.

CEA is part of 2 SATTs: one located in Saclay and another in Grenoble. CEA's projects may therefore benefit from SATT financing, but the proposed financial conditions remain binding and undermine the subsequent freedom-to-operate of the associated IP, which remains difficult to combine with CEA's business model.

Finally, it should be noted that more and more public funding requires a return on investment to the structure that supports them. Therefore, in order to be eligible for such external financing some projects (regrettably) go to the stage of business creation prematurely compared to the overall level of progress of the project, which can then weaken their chances of success.

It can be considered that the development of a young company is based on a succession of stages accompanied by a "go/no-go" decision-making process. Even if the technological challenges to be met are real, it also appears that the risk associated with each step is strongly dependent on the financial capacity that will make it possible to succeed or not. The exercise then requires the mobilisation of the different funding actors: if only one link fails then the entire development chain is blocked.

For its part, an investor will only agree to acquire an equity stake in the start-up company if it knows it can "exit" under suitable conditions. Each investor has its own definition of the "right" project (i.e. the one that meets its selection criteria) and in addition, the profile of potential investors depends on the type of business and the development stage it has reached.

The current dynamics of start-ups are strongly supported by public authorities (PIA, BPI, etc.) and the development of new external support and financing structures (SATT, incubators, accelerators, etc.).

However, these tools cannot fill the gaps in a financing system that remains at the national or even European level still insufficiently robust. Venture capital in Europe is, for example, much less developed than in the USA or in Asia (notably in China).

For deep tech start-ups, this often leads to state-of-the-art technologies developed and financed by national public funds, ultimately being transferred abroad by investors.

Why is this important in the age of globalisation? Simply because France and Europe risk losing new emerging technologies whose development would be controlled abroad – for example by US companies –, to the detriment of French / European intellectual capital.

In this regard, we can highlight the positive action of BPI to help in the structuring and strengthening of national venture capital. This action must also be supported at European level to help the emergence of venture capital with a critical size to support start-ups. This action is particularly strategic while the needs for investments in deep tech start-ups are strongly growing.

Finally, if the quantitative aspect is important, the duration with the proposed financing is also essential, and this even more for deep tech.

The duration of the investments must allow the development of technologies that start-ups will bring.

It was pointed out earlier that this duration could often exceed 10 years.

However, the maximum term of an investment fund is generally 10 years, after which the fund manager is committed to liquidating its assets. Given the delays in setting up a fund, in practice investors can support a project for an average of 6/7 years. But this timeframe is well below the needs of a deep tech start-up that will need more than 10 years to put its product on the market.

So, if we want strong businesses, an industry that is renewing itself, including start-ups and high-tech sectors, it is essential to be able to count on long-term capital invested. The development of strategic funds with the capacity to support longer investment times than is currently proposed is therefore a very strategic point.