RRI-Practice Deliverable 6.1: Report from national case study

CEA (France)

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1. Executive summary

Responsible research and innovation (RRI) has emerged, particularly in Europe, as a science policy framework seeking to:

a) engage publics and science & technology stakeholders in a responsible, multi-dimensional dialogue on 5 RRI "keys": ethics, science education, open access, gender, and public engagement.
b) achieve research and innovation outcomes that will influence society in a sustainable and ethically desirable way.

In France the RRI keys are rarely combined within a unified approach, even if the interaction with European agencies encourages a global vision on science and society. The actual structure of French research organizations corresponds to developing the RRI keys separately.

In each French research organization, certain keys are better developed than the others. Some, e.g. gender, possess a dedicated legal framework and indicators or are regulated at the national level. Ethics and integrity currently benefit from increased institutional attention due to government action launched in 2016. In contrast, public engagement is often better developed by NGOs than by public research organizations. French stakeholders perceive RRI primarily as a framework for sharing and improving best practices developed by different institutions.

Among best practices, we note several: a *mission pour la place des femmes* at CNRS (National Center for Scientific Research); ethics training at INRIA (National Institute for Computer Science and Control) and Inserm (National Institute of Health and Medical Research); public engagement effort at INRA (National Institute for Agricultural Research). CNES (National Center for Space Studies) and CEA have developed remarkable science education initiatives. INRIA is unique in evaluating its researchers based only on open-access publications deposited in HAL (National Open Archive).

The national study and the analysis of RRI at CEA show that the notion of responsibility is often tightly linked with Corporate Social Responsibility (CSR). This conceptual continuity with an approach launched by UNESCO in 1974 should be maintained as it provides historical and organizational continuity. RRI is not a revolution but marks an era of increased attention to societal concerns.

Our findings show that, in science, the term 'responsibility' often provokes a feeling of being accused of irresponsibility: the development of RRI should not imply relativism or a loss of autonomy.

At the organizational level, main drivers of RRI keys at CEA are almost exclusively structural and often originate in regulatory measures. The translation of culture-inspired initiatives into structural measures is therefore essential.

RRI barriers in France are specific to each key. For example, traditional forms of public engagement, e.g. public debates, have shown their limits, particularly concerning inclusivity. In ethics, we observe a 'delegation effect': ethics is turned into a specialized task for dedicated

committees, instead of engaging all researchers in ethical reflection at the time they conceive innovative projects.

Our recommendations for particular keys include:

- Diversify public engagement modalities, in particular through highly effective Art & Science initiatives;
- Institutionalize science education activities through formal partnerships with the Ministry of National Education;
- Create a national coordination for science education between research organizations in order to promote up-to-date scientific content in high school programs;
- Increase the rate of women among scientists, especially in disciplines with a low rate, by installing a recruitment rate 5 points higher than the rate among existing personnel, and promote symbolic measures, e.g. the nomination of women to top-level management positions;
- Develop ethical training at the doctoral and master's level following high-quality methodological guidelines;
- Evaluate researchers based on open access publications in HAL;
- Act at national and European levels in order to stop the financial double penalty created by ever more expensive journal subscriptions and the need to pay for open access.

2. Methodology

2.1 Meetings and discussions

Following the common analytic approach of the RRI-Practice project[1], we conducted 29 document studies and 16 interviews with stakeholders. A national workshop was organized on February 24th, 2017. A CEA focus group meeting took place on February 15th, 2018.

During the preparation of this report we visited four CEA centers, where we had extensive discussions on several or all RRI keys. We found interested and engaging interlocutors at the CEA General Division (*Direction générale*), to whom we remain deeply grateful for their help and insights. We had a rare opportunity to present the RRI-Practice project, its methods and results, to the CEA Administrator General during a 2-hour meeting on February 5th, 2018. We also benefited from fruitful communication and support from the Cabinet of the Administrator General, particularly the Executive Officer for Sustainable Development.

The outlooks are presented are the end of each section under the name "points of improvement."

2.2 Document analysis

A total of 29 documents have been studied during preparation of this report:

	Title	Date	Status
1.	ComCoord Ancre sur l'intégrité scientifique	31/05/2017	Confidential
2.	Lettre circulaire du MENESR N°2017-040	15/03/2017	Public
3.	Vade-mecum du MENESR sur l'intégrité scientifique	21/06/2017	Public
4.	Charte nationale de déontologie des métiers de la recherche	26/01/2015	Public
5.	Stratégie nationale de recherche	03/2015	Public
6.	Académie des technologies. Quelques réflexions sur la question de l'appropriation des technologies	13/05/2015	Public
7.	ALISS Livre blanc « Prendre au sérieux la société de la connaissance »	03/2017	Public
8.	Arrêté relatif au collège de déontologie au sein du ministère chargé de l'enseignement supérieur et de la recherche	01/03/2018	Public
9.	Stratégie nationale de culture scientifique, technique et industrielle	09/03/2017	Public
10.	Assemblée nationale. Résolution sur les sciences et le progrès dans la République.	21/02/2017	Public
11.	Le développement durable du CEA. Idées issues du groupe de créativité	10/2017	Confidential
12.	Diffusion de la culture scientifique et actions pédagogiques CEA Cadarache	05/05/2017	Confidential
13.	CEA Contrat d'objectifs et de performance 2016-2020	2016	Public

[1] RRI-Practice project description, Part B (available at www.rri-practice.eu) .

14.	Stratégie du développement durable et d'engagement responsable du CEA	05/2017	Public
15.	CEA en chiffres	2016	Public
16.	Moi au CEA. Enquête d'opinion interne	2017	Confidential
17.	Compte-rendu de la Commission centrale sur l'égalité professionnelle du CEA	16/05/2017	Confidential
18.	Projet de « Charte de la participation du public dans le cadre de la démocratie participative »	12/2016	Public
19.	Bilan et propositions de mise en œuvre de la charte nationale d'intégrité scientifique	29/06/2016	Public
20.	France Europe 2020. A Strategic Agenda for research, technology transfer and innovation	05/2013	Public
21.	Enquête DRHRS « Perception de l'égalité femmes/hommes au CEA ». Analyse des résultats.	14/03/2015	Confidential
22.	Enquête DRHRS « Perception de l'égalité femmes/hommes au CEA ».	2013	Confidential
23.	Rapport de S. Bauin « L'Open access à moyen terme : une feuille de route pour HAL »	09/2014	Public
24.	La lettre du Clora	27/06/2017	Public
25.	Open Access: l'appel de Jussieu	06/07/2016	Public
26.	Stratégie nationale de recherche. Rapport de propositions et avis du Conseil scientifique de la recherche	03/2015	Public
27.	Revue VRS « Condition et responsabilité du chercheur »	11/2016	Public
28.	The SOLSTICE programme: Citizen Weather and Climate Observer Programme by Pupils from the Euro-Mediterranean Region	2016	Confidential
29.	Visiatome brochure	2018	Public

2.3 Interviews

All interviews were conducted between April 2017 and May 2018. Individuals who were interviewed occupy the following positions:

		Place of interview
1.	Administrator General	Saclay
2.	High Commissioner for Atomic Energy	Paris
3.	Executive Officer for Sustainable Development	Saclay
4.	Executive Officer for Compliance	Saclay
5.	Director of Strategic Analysis	Saclay
6.	Human Resources Directorate, Project manager for Conduct of change	Saclay
7.	Unit for scientific and technical support, Project manager	Saclay
8.	Communication Department, Head of Unit for Science Education	Saclay
9.	Communication Department, Deputy Director	Saclay
10.	Communication Unit, GIANT Executive Board Coordinator	Grenoble
11.	Communication Unit, Head of Unit	Cadarache
12.	Communication Unit, Project manager for science education	Cadarache
13.	Communication Unit, Head of Unit	Marcoule
14.	Director of OpenLabs	Grenoble

15.	Communication Unit, Project manager for Nano@school	Grenoble
16.	Scientific Integrity Officer	Saclay

3. RRI context: the national science policy system

3.1 General country information[2]

France, with its illustrious scientific tradition, plays an important part in the worldwide research effort. Public research is centered on the multidisciplinary *Centre National de la Recherche Scientifique* (National Center for Scientific Research, CNRS). There also exist numerous specialized public research organizations, including CNES[3], CEA[4], INSERM[5], INRA[6], INRIA[7], IRSTEA[8], Observatoire de Paris[9], IRD[10], CIRAD[11], Institut Curie[12], Institut Pasteur[13], etc. These organizations possess different legal statuses: CNRS, INSERM, INRA, INRIA, IRSTEA and IRD are 'public establishments with a technical and scientific purpose' (*établissements publics à caractère scientifique et technique*, EPST) and their employees are public servants, while CNES and CIRAD are 'establishments with an industrial and commercial purpose' (*établissements à caractère industriel et commercial*, EPIC), and CEA is a public establishment with a scientific, technical and industrial purpose (*établissement public à caractère scientifique, technique et industriel*). The employees of the last three structures are subject to private sector labor laws. The other structures also enjoy a particular legal status. Besides pure research organizations, universities and *grandes écoles* (selective higher education institutions with an admission exam) employ professors who conduct research and dedicate a part of their work time to science.

Counting researchers and support staff together, close to 575,300 persons dedicate their work to R&D in France in 2014 for at least part of their activity. This is equivalent to approximately 417 000 full-time positions or 2.2% of the 25.8 million workforce. The number of researchers in 2015 was 266,700. At the beginning of the 2015-2016 school year, the teaching and research potential in public higher education under the authority of the Ministry of Higher Education and Research (*Ministère de l'Enseignement Supérieur et de la Recherche*, MESR) was 90,500 professors and researchers.

[2] Sources: *Ministère de l'enseignement supérieur et de la recherche; Stratégie nationale de recherche.*

[3] www.cnes.fr

[4] www.cea.fr

[5] www.inserm.fr

[6] www.inra.fr

[7] www.inria.fr

[8] www.irstea.fr

[9] www.obspm.fr

[10] www.ird.fr

[11] www.cirad.fr

[12] www.curie.fr

[13] www.pasteur.fr

In 2014, R&D in France was worth 47.9 B€, 2.24 % of GDP. France is behind South Korea (4.3 %), Israel (4.1 %), Japan (3.6 %), Germany (2.9 %) and the United States (2.7 %), but ahead of the UK (1.7 %). In 2015, this figure went up to 49.8 B€ (2.27% GDP)[14].

R&D investments from private firms represent 63.8% of that amount, or 31.8B€[15]. Despite a continuous progression supported by dedicated fiscal deductions (*Crédit Impôt Recherche,* CIR), R&D efforts from the French private sector lag behind those recorded in most developed economies. This particular weakness can be partly explained by the reduction in scope of the French industry in the last decades.

France ranks 7th worldwide for scientific publications[16], 3rd in mathematics, and in the top positions for certain disciplines such as fundamental biology, applied biology and ecology, or physics and atmospheric sciences. France is also internationally renowned for its expertise in large scale international equipment. The country ranks 3rd for its number of recipients of European Research Council grants. During the 2006-2018 period, French scientists have been awarded a Turing prize[17], four Breakthrough prizes[18], two Lasker prizes[19], four Fields medals[20] and seven Nobel prizes and one Prize for Economic Sciences ("Nobel Prize for Economics")[21].

In 2014, France ranked 4th worldwide in the European patent system (6.3% of recorded patent applications). The country specializes in 'transportation', 'nanotechnologies, microstructures', 'fine organic chemistry', 'materials, metallurgy' and 'eco-technology'.

The French scientific research effort is spread throughout the entire territory, with particularly important emergent clusters such as *Île-de-France* (Paris), *Rhône-Alpes* (Lyon and Grenoble), *Occitanie* (Toulouse), *Provence-Alpes-Côte-d'Azur* (Nice and Aix-Marseille), *Aquitaine* (Bordeaux) and *Grand Est* (Strasbourg and Nancy).

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[14] See the official website of the Ministry of Higher Education, Research and Innovation: http://www.enseignementsup-recherche.gouv.fr/pid25351-cid124745/depenses-de-recherche-et-developpement-en-france-resultats-detailles-pour-2015-et-premieres-estimations-pour-2016.html

[15] *Idem*, http://m.enseignementsup-recherche.gouv.fr/cid115575/les-depenses-de-r-d-des-entreprises-en-2015-donnees-provisoires.html

[16] *Idem*, https://publication.enseignementsup-recherche.gouv.fr/eesr/FR/T033/la_position_scientifique_de_la_france_dans_le_monde_a_travers_ses_publications/

[17] Joseph Sifakis: https://amturing.acm.org/byyear.cfm

[18] Emmanuelle Charpentier (Life Sciences), Alim Louis Benabid (Life Sciences), Michel Della Negra (Fundamental Physics), Maxim Kontsevich (Fundamental Physics): https://breakthroughprize.org/

[19] Alim Louis Benabid, Alain Carpentier : http://www.laskerfoundation.org/

[20] Artur Avila, Ngô Bào Châu, Cédric Villani, Wendelin Werner: https://www.mathunion.org/imu-awards/fields-medal

[21] Serge Haroche, Albert Fert (Physics), Jean-Pierre Sauvage (Chemistry), Patrick Modiano, Jean-Marie Gustave Le Clézio (Literature), Françoise-Barré Sinoussi & Luc Montagnier (Medecine, 2008), Jean Tirole (Prize for Economic Sciences) : https://www.nobelprize.org/nobel_prizes/lists/all/index.html

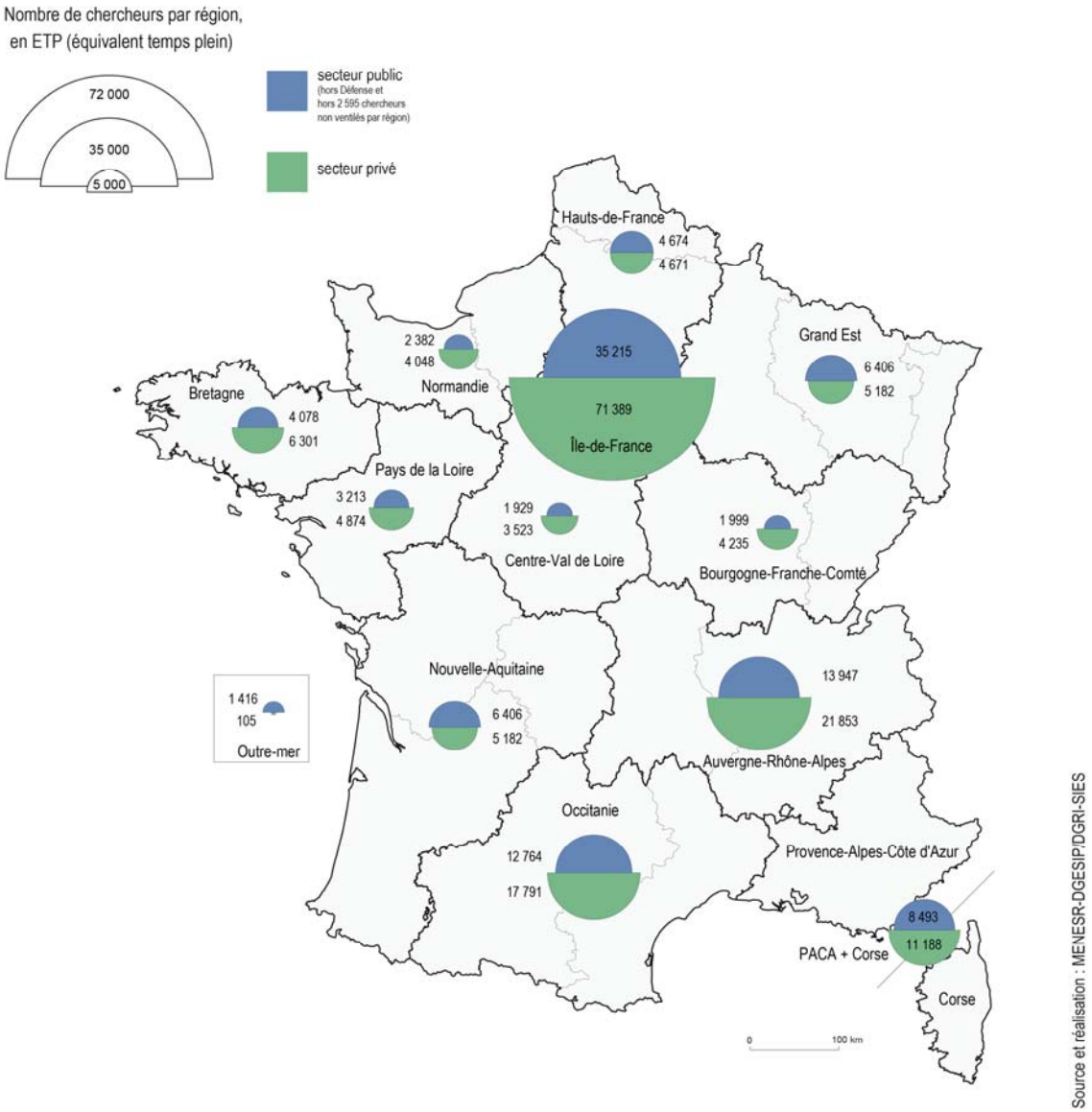

Figure 1. Distribution of researchers per region (source: MENESR).

3.2 Legal and regulatory framework

***Stratégie Nationale de Recherche*[22]**

Inscribed in the July 22nd 2013 law on higher education and research, the 'national research strategy' (S*tratégie Nationale de Recherche,* SNR) has a double ambition: maintaining France as one of the leading powers in international research, and allowing French research to face the scientific, technological, environmental and societal challenges of the 21st century.

***Agenda stratégique France Europe 2020 pour la recherche, le transfert et l'innovation*[23]**

"France Europe 2020" is the strategic roadmap for research, technological transfer and innovation set in motion by the Ministry of Higher Education and Research. It defines national priorities and specific measures to foster technological transfer and innovation, while maintaining France place in the European research space.

***Charte nationale de déontologie des métiers de la recherche* (January 26th 2015)[24]**

The national deontology chart for research jobs constrains all signing research institutions to adopt a variety of measures fostering best practices in research, as well as sensitivity training of their employees and students to those practices. It also states deontological guidelines, and implements clear and well-publicized procedures to prevent and treat possible violations of deontological rules.

***Lettre-circulaire du MENESR* (March 15th 2017[25])**

This circular letter from the Ministry of Higher Education and Research promotes a scientific integrity policy, including the treatment of possible violations, among higher education structures and their groupings, research institutions, scientific cooperation foundations and other public organizations of higher education and research. General principles are clearly stated, and their modalities of enforcement are determined. A vade-mecum is appended to the letter. The letter creates an obligation for all signatories to hire a scientific integrity officer.

[22] http://www.enseignementsup-recherche.gouv.fr/cid86746/strategie-nationale-recherche-rapport-propositions.html

[23] http://www.enseignementsup-recherche.gouv.fr/cid71873/france-europe-2020-l-agenda-strategique-pour-la-recherche-le-transfert-et-l-innovation.html

[24] http://www.cnrs.fr/comets/IMG/pdf/charte_nationale__deontologie_signe_e_janvier2015.pdf

[25] http://circulaires.legifrance.gouv.fr/pdf/2017/03/cir_41955.pdf

***Loi relative à l'accès à l'emploi titulaire et à l'amélioration des conditions d'emploi des agents contractuels dans la fonction publique, à la lutte contre les discriminations et portant diverses dispositions relatives à la fonction publique* (loi Sauvadet, March 12th 2012)[26]**

Among other dispositions, this law introduces numeric targets for a balanced representation of women and men in the public service.

***Protocole d'accord égalité professionnelle Femmes-Hommes dans la fonction publique* (March 8th 2013)[27]**

On March 8th 2013, a memorandum on professional equality between women and men in public service was signed under the aegis of the government by ten trade unions and the entire set of public employers.

***Loi relative à l'enseignement supérieur et à la recherche* (loi Fioraso, July 22nd 2013)[28]**

This law contains several clauses relative to professional equality between women and men in higher education and research. It imposes a rule of strict parity in the composition of administrative boards and academic councils in higher education institutions and within the Research Strategic Council (*Conseil stratégique de la recherche*) created by this law.

***Circulaire relative à la prévention et au traitement du harcèlement sexuel au travail dans les établissements publics de l'enseignement supérieur et de la recherche relevant du MENESR* (November 25th 2015)[29]**

This circular letter strengthens measures to fight sexual harassment in higher education and research, in particular through supporting the creation of specific procedures to prevent and repress sexual harassment.

3.3 Cultural and political values related to science, technology and innovation

Several French texts proclaim political and cultural values essential to scientific research. A set of typical values can be found in such documents[30], in particular freedom of research and its excellence. The importance of the rationalist and humanist tradition is also underlined.

The most recent documents insist on the intelligibility of science for citizens and define the understanding of the world we live in as a mission of scientific research.

[26] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000025489865&categorieLien=id

[27] https://www.fonction-publique.gouv.fr/files/files/publications/politiques_emploi_public/20130308-Protocole-d-accord-egalite-professionnelle.pdf

[28] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000027735009&categorieLien=id

[29] http://www.enseignementsup-recherche.gouv.fr/pid20536/bulletin-officiel.html?cid_bo=95478&cbo=1

[30] M. Ladikas et al. (eds.), *Science and Technology Governance and Ethics. A Global Perspective from Europe, India and China*. Springer Open, 2015.

Controversies on scientific expertise are part of the current political debate: "If there is a debate on GMOs, nuclear power, or nanotechnologies, it is because some individuals or groups have expressed—without asking for a permission—their *political* opposition to those *political* projects."[31]

The expression "without asking for a permission" is a matter of interpretation. It probably means that some members of civil society would feel a lack of public concertation on scientific and technological choices, or do not acknowledge the legitimacy of existing consultations. Such protests exemplify the tension between representative democracy and direct democracy in the debates regarding scientific and technological orientations. This has led representative instances, e.g. the *Assemblée Nationale* (National Assembly), to wonder what place democratic procedures have in science-society relations, because a confusion between scientifically proven knowledge and simple opinion seems unavoidable for citizens without scientific training.

National research strategy (*Stratégie Nationale de Recherche*)

The national research strategy (see above) states several key underpinning values of French research, such as "freedom, with a requirement of excellence." According to the national research strategy, an open innovation logic defines the framework of groundbreaking technological research. Centered on societal challenges, the national strategy "puts human beings and society at the core of its definition." It reads: "It is imperative that [research] objectives be intelligible for citizens and that the expected spin-offs be expressed in clear and legible terms." Considering the uncertainties at the core of the development of new technologies, reaching such an intelligibility is a heavy task, which rests on the shoulders of the entire scientific community.

***Résolution de l'Assemblée nationale sur les sciences et le progrès dans la République* (February 21st 2017)[32]**

In February 2017, the *Assemblée Nationale* adopted a resolution on science and progress in the French Republic. It contains a unique article, opening with a statement that science is an essential vector of innovation but also a common good which widens cultural perspectives of all citizens looking for a better understanding of the world.

This resolution identifies a set of core values of the French Republic concerning science and progress, such as:

- "science at the service of humankind",
- "science as an heir to a deep rationalist tradition and the philosophy of the Enlightenment" ,
- "scientific culture is the basis of every research for true knowledge" ,
- "scientific culture is indispensable for enlightened and responsible citizens".

[31] Source: http://www.slate.fr/france/83845/les-activistes-anti-techno-de-pmo-nous-expliquent-leur-strategie

[32] http://www.assemblee-nationale.fr/14/ta/ta0926.asp

The resolution simultaneously underlines existing controversies regarding the role of science in our society:

- "Partisan and even sectarian speeches founded on a growing disregard for scientific expertise call into question the spirit of the Enlightenment",
- "The confusion between knowledge and opinion is a severe threat to the well-functioning of democracy".

It is yet another task of the scientific community to draw a line between, on the one hand, gratuitous accusations of obscurantism and "scientific denial" and, on the other hand, the true need to implicate civil society in democratic choices pertaining to technological development.

National strategy of scientific, technological and industrial culture (March 2017)

According to the national strategy for scientific, technological and industrial culture (*Stratégie nationale de culture scientifique, technique et industrielle*), which follows the definition given by the *Association des musées et centres pour le développement de la culture scientifique, technologique et industrielle* ("Association of museums and centers for development of scientific, technological and industrial culture", AMCSTI), cultural values contain values relative to science: scientific culture is "part of culture in the broadest sense; it must allow citizens to understand the world they live in, and prepare for the world of tomorrow. This culture develops information and reflection on science and its issues, fosters exchanges with the scientific community, shares knowledge, educates for an active citizenship: it thus inscribes science within society." Its first objective is understanding: " 'scientific, technological and industrial culture' shows a desire to comprehend the evolution of science and technology as a whole, and to understand the relations between science, technologies, industry and society."

The mission of scientific and technological culture is thus defined: "To build and rebuild a positive representation of science and technology, to bring back trust in the values of progress, while acknowledging that part of actual discoveries raises fundamental ethical issues, such are the challenges we must face to reinforce the pedestal of our scientific democracy."

To summarize, science counts among values proclaimed on multiple occasions in the French Republic. A key issue is finding a way to connect this high-level declaration with the lives of the citizens of the Republic.

4. Aspects of responsibility in French science policy

4.1 Conceptualization of responsibility in French science policy

In the official documents defining the operation of French research, the concept of "responsibility" occurs only occasionally. In most cases, it is mentioned in the context of "social responsibility of corporations" (*responsabilité sociale des entreprises,* RSE). This concept has been used by UNESCO since 1974, and its application to the domain of scientific research is now being debated and reviewed. In November 2017, the Recommendation voted in 1974 has been amended by the UNESCO General Conference. The responsibility of scientists is defined in the context of universal values: "The Recommendation underlines the responsibility of science with towards the United Nations' ideals of human dignity, progress, justice, peace, the well-being of mankind and respect of the environment[33]."

In order to prepare a contribution to the revision of the 1974 Recommendation, trade unions of the research organizations have organized at the *Centre national des arts et métiers* (CNAM), on September 8th, 2016, a conference on "The Researcher's Condition and Social Responsibility".

The social responsibility of researchers towards employers was at the heart of debate[34]. A member of Parliament Jean-Yves Le Déaut, then president of the Parliamentary Office for Scientific and Technological Assessment (*Office parlementaire d'évaluation des choix scientifiques et technologiques*, OPECST), stressed at the conference that the researcher "should be able to enforce her right to withdraw, to maintain her independence as an expert and a whistleblower, to not use research for destructive purposes, in particular through the application of the precautionary principle. She must aim for the objective of social well-being, maintain her integrity in the conduct of her work and take part in citizens' debates." In contrast, the union representative Hervé Christofol, general secretary of the SNESUP[35], stressed the role of social responsibility in "the researcher's resistance to the excesses of managers and the subjugation of minds to special interests." According to him, "social responsibility must guarantee that general interest, collective responsibility and better training to ethical practices and deontological rules prevail over special interests and individualization of responsibility."

The rest of the debates focused on questions relative to the functioning of research, for instance the introduction of competition in the research community and the lack of human and financial means in French scientific research.

Contrary to the concept of "responsibility", the five RRI keys play an important role in the French scientific system. The national research strategy contains many propositions pertaining to science education and dissemination of scientific knowledge. For instance, the priority action "Bioeconomy for the energetic and ecological transition" proposes an "ethical reflection *ab*

[33] Unesco. Records of the General Conference. 39th Session. Paris, p.75: http://unesdoc.unesco.org/images/0026/002608/260889e.pdf
[34] Revue VRS, n° 406, automne 2016.
[35] http://snesup.fr/intervention-du-snesup-fsu-lors-du-colloque-de-la-cnfu

initio allowing a relevant integration of social sciences." In this text, there are also explicit recommendations relative to the implementation of projects along RRI keys, for instance:

> Orientation #30: Social, pedagogical and cultural innovations. Social, pedagogical and cultural innovations are both numerous and useful. Their study constitutes a new field which will propose modalities of anticipation allowing for a better promotion of those innovations, and a better adaptation and integration of the entire population to the subsequent social transformations. In particular, it will become necessary to develop new methodologies including a rigorously conducted comparative dimension, and to establish new frames of reference to evaluate social progress by taking into account subjective variables, such as perceived well-being[36].

The relative lack of interest for the concept of "responsibility" is thus compensated by the attention brought to RRI keys and RRI dimensions, especially anticipation.

4.2 RRI in French science policy debates

In France, the concept of Responsible Research and Innovation is essentially used in the context of research projects funded by the European Commission, such as the Horizon 2020 program. However, due to abundant participation of French actors in such projects, the concept of RRI is starting to spread in the scientific community. Several research institutions, e.g. CEA and INSERM, have established workgroups on RRI, aiming at a better understanding of its issues and an operational translation of RRI adapted to each institution.

At the national level, the concept of RRI is not explicitly mentioned in calls for proposals operated by the National Research Agency (*Agence Nationale de la Recherche,* ANR). It sometimes occurs implicitly, as for instance in collaborative projects funding program "MRSEI Construction de l'Espace Européen de la Recherche – 2016[37]". In 2017, some ERANET[38] and ANR collaborative calls have integrated RRI for the first time in nationwide calls for tender, such as *ERA-Net Cofund on Biotechnologies*[39] or EURONANOMED III joint transnational call for proposals (2017) for "European innovative research and technological development projects in nanomedicine"[40]. Those flagship projects in RRI are often dedicated to biotechnologies and medicine, functioning at both national level (ANR) and European level (H2020 program). They serve as a dissemination vector for RRI in France. Unsurprisingly, as of summer 2017, the French institution most involved in RRI discussions at both national and international level was a medical research institution, INSERM.

Even if the need to spread the notion of RRI at national level is not directly mentioned in any official document, RRI keys are constantly brought to the fore. In its March 15th, 2017, a circular

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[36] Translated from the « Stratégie nationale de la recherche : rapport de propositions et avis »: http://cache.media.enseignementsup-recherche.gouv.fr/file/Strategie_Recherche/69/3/rapport_SNR_397693.pdf

[37] http://www.agence-nationale-recherche.fr/projets-finances/?tx_lwmsuivibilan_pi1[Programme]=1031

[38] "The ERA-NET instrument under Horizon 2020 is designed to support public-public partnerships in their preparation, establishment of networking structures, design, implementation and coordination of joint activities as well as topping up of single joint calls and of actions of a transnational nature": http://ec.europa.eu/research/era/era-net-in-horizon-2020_en.html

[39] http://www.agence-nationale-recherche.fr/fileadmin/aap/2017/aap-cobi-2017-v2.pdf

[40] http://www.agence-nationale-recherche.fr/fileadmin/aap/2017/aap-enmiii-2017.pdf

letter from the Ministry of Higher Education and Research outlined that"in the long run, the ANR will condition project funding on a declaration by the benefiting institution of an effective implementation of ethics and scientific integrity policy."

4.3 Ethics in French research system

Description of current practice and its dynamics: general review

In research institutions as well as in universities, research ethics is taken into account through the creation of ethics committees. Those committees can take three different forms: "reflection committees", whose mission is to publish recommendations on research ethics issues (CERNA at Allistene[41], COMETS at CNRS[42]); "operational committees", which have a right of inspection of particular projects led by research teams, often enjoying a status of Institutional Review Board (COERLE at INRIA[43], *Comité d'éthique* at INSERM[44], etc.); and "missions" dedicated to integrity and deontology.

Ethics committee for non-interventionist research[45] (CERNI) also exist in some universities, such as Toulouse[46], Grenoble[47] and *Université Paris-Saclay*[48]. Other universities have created ethics committees for projects involving human research, such as *Université de Lille*[49].

As mentioned above, the MENESR circular letter makes mandatory the creation of a scientific integrity officer in each research institution. INSERM, in particular, has played a pioneering role by creating its own delegation for scientific integrity as early as 1999. HCERES, which is in charge of the evaluation of research laboratories, demands that any evaluated institution has a structure dedicated to ethics.

National framework for animal experimentation

The European legal framework for animal experimentation is defined by the September 22nd 2018 2010/63 directive on the protection of animals used for scientific purposes. The directive rests essentially upon the 3R principle: Reduce (the numbers of animals used in experiments), Refine (the methodology), Replace (animal models). A re-examination of directive 2010/63 is scheduled for 2019.

[41] Allistene is an alliance of institutions interested in the social and economic changes caused by digital technologies: www.cerna-ethics-allistene.org

[42] http://www.cnrs.fr/comets/

[43] https://www.inria.fr/en/institute/organisation/committees/coerle/presentation-of-the-coerle

[44] https://www.inserm.fr/qu-est-ce-que-l-inserm/l-ethique-a-l-inserm

[45] "Non-interventionist research" denotes experimental research without animal or human biomedical experimentation.

[46] http://www.univ-toulouse.fr/recherche-doctorat/recherche/comite-d-ethique

[47] http://www.grenoblecognition.fr/index.php/ethique/ethique-soumettre-un-dossier

[48] https://www.universite-paris-saclay.fr/fr/polethis

[49] https://www.univ-lille3.fr/recherche/presentation-et-missions/comite-ethique/

In this perspective, the four French academies (sciences, medicine, pharmacology, and veterinarian) have addressed on November 14th 2017 their five recommendations on the protection of animals to the European Commissioner for the Environment: (i) reinforce the vigilance on the enforcement of legislations imposing to respect the regulatory and ethical framework formalized by directive 2010/63; (ii) use animals only in the absence of a relevant substitute method and after an opinion from the ethics committee; (iii) improve the well-being of animals used in scientific protocols; (iv) re-examine and alleviate regulatory procedures on drugs' marketing authorization in the light of recent scientific developments, in order to reduce animal experimentation; (v) respond in an clear and pedagogical manner to all opponents to animal experimentation.

In France, FRANCOPA is a Group of Scientific Interest (*Groupement d'Intérêt Scientifique*, GIS) gathering all stakeholders of animal experimentation (regulatory bodies, administrations, researchers, animal protection NGOs) which was created in 2008 in order to promote alternatives to animal experimentation. During 2017, a reflection was conducted with research institutions to adapt FRANCOPA to the evolutions of regulatory frameworks and researchers' needs. This reflection should come to a conclusion in the course of 2018 with the creation of a French center dedicated to the 3R approach.

According to current regulations, the composition of ethics committees must be multi-disciplinary and include persons competent in the conception and implementation of experimental procedures, in animal medical care and euthanasia, as well as members who are not specialized in animal testing issues.

At the end of 2017, the Ministry of Higher Education, Research and Innovation has sent to every French ethics committee a document defining the "Common rules of organization and functioning of ethics committees on animal experimentation[50]". This document was elaborated at the request of the Ministry by GIRCOR (*Groupe Interprofessionnel de Réflexion et de Communication sur la Recherche,* Interprofessional Group of Reflection and Communication on Research*)*, and followed the recommendations of the National Committee on Ethical Reflection on Animal Experimentation (*Comité National de Réflexion Éthique sur l'Expérimentation Animale*). It defines in detail the modalities of recruitment and renewal of committee members, the conduct of debates, the constituent parts of internal regulation, and the activity report. The main objective of this document is to harmonize the functioning of French animal ethics committees in order to ensure homogeneous project evaluations.

Main barriers (structural, cultural or related to interchange dynamics)

It is often believed that ethics is hard to combine with the execution of operational tasks falling to each scientist involved in a research team. From a structural point of view, there is no room for ethical thinking in the day-to-day schedule of researchers, and in the organizational chart of operational divisions. It is delegated to dedicated ethics committees, which sometimes struggle

[50] https://www.recherche-animale.org/sites/default/files/gircor-grice_regles_communes_organisation_et_fonctionnement_des_comites_ethique_en_experimentation_animale_mars_2018.pdf

to create a real contact with researchers. It is not unusual that scientific personnel perceives ethics as an activity under the sole responsibility of the ethics committee, therefore "liberating" researchers from the obligation to take care of it.

In order to avoid the creation of such a gap between ethics committees and the everyday reality of research laboratories, it has been proposed to adopt a "diffuse ethics" approach (*éthique diffuse*) in research institutions and universities. This would allow to spread a sense of ethical responsibility at every level of a research institution, from management to researchers. This approach would help anchoring the notion of RRI. On the other hand, it demands a strong contribution in labor time from every scientist, threatening the good execution of research tasks. Practice has shown that this approach remains largely theoretical in research institutions[51]. At the same time, it could become more effective if the diffusion would take place through civil society, such as in regional ethical spaces (*Espaces éthiques régionaux*), especially in the *Espace éthique d'Île-de-France*[52].

Main drivers (structural, cultural or related to interchange dynamics)

In the last decades, in France and all over the world, one observes a proliferation of ethics committees. This evolution is based on deep cultural and historical trends. Because of the development of new technologies and the increased awareness of risks for humans and for the environment, the public is more and more aware of the transformational power of science over society. From a cultural point of view, one observes a growing demand for ethical thinking about new technologies. Among stakeholders in science and technology, there is also a growing feeling that the model of an autonomous "republic of science"[53], pejoratively known as 'the ivory tower', no longer corresponds to reality.

From an institutional point of view, the creation of ethical committees in research institutions follows two different paths. On the one hand, and most frequently, it is a reaction to a need expressed within those organizations, to which the direction of an institution or a group of institutions (for instance, the *Alliance Allistene*) has to react. This was the case with the creation of the CERNA commission[54] or the operational ethics committee at INRIA (COERLE[55]). Further back in time, in 1983 France was the first country in the world to create a *Comité Consultatif National d'Éthique pour les sciences de la vie et de la santé* (National Consultative Committee for Life and Medical Sciences Ethics, CCNE)[56]. This creation was an institutional answer to the debates sparked by the birth of Amandine, the first child conceived in France

[51] Séminaire National RRI, 24 Février 2017.
[52] http://www.espace-ethique.org/
[53] M. Polanyi, "The Republic of Science", Minerva, 1(1), 1962, pp. 54-73. The concept was also used in the JERRI (Joining Efforts for Responsible Research & Innovation) Project, in its report "Deepening 'Deep Institutionalization'": https://www.jerri-project.eu/jerri-wAssets/docs/deliverables/wp-1/JERRI_Deliverable_D1_2_Deepening-Deep-Institutionalisation.pdf
[54] http://cerna-ethics-allistene.org/
[55] https://www.inria.fr/en/content/search/(keyword)/COERLE
[56] http://www.ccne-ethique.fr/fr/pages/historique

through in vitro fertilization, in 1982[57]. Consequently, the first issues studied by the committee were consequently medically assisted procreation and human experimentation, but its current topics also span human embryo, access to genetic information, neuroscience, the status of human body parts, biodiversity and the concept of consent[58]. On the other hand, operational committees and scientific integrity officers are sometimes the product of a vertical governance structure, a consequence of a decision from authorities or of constraints imposed at the national or European levels (ANR and European Commission).

There is a permanent, if informal, dialogue between various ethics committees, via mutual invitations, presentations in seminars and discussions of concrete cases. For instance, after the last meeting of institutional ethics committees on November 29th 2017, it was decided to make such meetings annual. Those exchanges give a certain coherence to the global ethical reflection in the French research system, and establish France as one of the models to be followed in research ethics.

Best practices

A research institution can have a complete structure dedicated to ethics and scientific research integrity. This is the case for INSERM or INRIA, among others. Such a structure contains:

- A reflection ethics committee. It can act at the request of the institution management, and can also act on its own initiative. Its membership contains employees of the institution and outside experts. Its mission includes publication of advisory opinions on ethical issues, and prospective on emerging ethical problems in the institution's domain;
- An operational ethics committee functioning like an IRB (*Institutional Review Board*). Upon request from research teams or individual researchers, this committee studies projects in which they are involved, or wish to work on. It gives a binding opinion on each project and acts as a point of reference during project implementation. This committee includes scientists, managers and legal experts;
- A scientific integrity officer. An integrity mission can be given to an individual or a group of individuals who enjoy an international reputation in their field and are independent of the institution management. This officer deals with breaches of integrity such as plagiarism and fraud. She recommends concrete measures to management according to the nature of the case.

[57] https://fr.wikipedia.org/wiki/Comit%C3%A9_consultatif_national_d%27%C3%A9thique
[58] http://www.ccne-ethique.fr/en/pages/history

4.4 Societal engagement strategies in research

Description of current practice and its dynamics: review of its operation

In various declarations and official documents from the authorities, the importance of science-society interaction, citizen science and participative science, engagement of citizens in decisions pertaining the deployment of new technologies and debates on scientific research is constantly highlighted.

For instance, in its February 21st 2017 Resolution on sciences and progress in the Republic (*Résolution sur les sciences et le progrès dans la République*), the *Assemblée Nationale* "invites the Government to set forth communication strategies and debates with citizens, which are adapted to the estimation and management of technological risks. The main issue of scientific and technological expertise is to give such an estimation prior to political decision. It is thus convenient to develop review procedures to shed light on societal debates. It is also convenient to draw a clear line between the possible intrinsic dangers of a technology and the risks inherent in its use. Those review procedures should establish a cost/benefit balance (socio-economical, environmental and sanitary) for adopting a technology and, as the case may be, for giving up that technology."

Several French institutions are responsible for the organization or facilitation of societal debates on scientific and technological issues. The most important one is the *Office parlementaire d'évaluation des choix scientifiques et technologiques* ("Parliamentary Office for Technological and Scientific Assessment", OPECST[59]): it organizes meetings, conducts studies on cutting-edge issues, and publishes reports for all stakeholders, including citizens and government. Since July 2017, OPECST is chaired by the Fields medalist and member of Parliament Cédric Villani.

Another major stakeholder of scientific culture in France is the Association of museums and centers for the development of scientific, industrial and technical culture (*Association des musées et centres pour le développement de la culture scientifique, technique et industrielle,* AMCSTI[60]). It gathers several dozen local, regional and national centers, including science museums and other spaces dedicated to the dissemination of scientific culture. In Paris as well as in province, the premises of the AMCSTI members are venues of scientific and technological debates. The AMCSTI is also a contact point for the "Science with and for society" component of the H2020 European program.

[59] http://www2.assemblee-nationale.fr/15/les-delegations-comite-et-office-parlementaire/office-parlementaire-d-evaluation-des-choix-scientifiques-et-technologiques

[60] https://amcsti.fr/

Main barriers (structural, cultural or related to interchange dynamics)

Recent polls show that most French citizens are interested in science and trust its ability to find solutions to societal problems[61]. Almost 80% of French people believe that scientific and technological innovations in the last twenty years had a positive impact on society[62]. However, only a quarter of citizens believe they are sufficiently informed on debates and issues pertaining to scientific research[63].

The organization of a public debate on scientific and technological issues raises several deep structural problems. In the general public as well as among certain decision-makers, there exists a temptation to reason in terms of a binary opposition between "scientists", perceived as "experts" on any topic, and the lay public who would be completely ignorant of recent scientific results methods. Such a representation is rather remote from the reality of current, highly specialized research; for example, an AI researcher might know nothing of synthetic biology, and a nanotechnology specialist may not at all be versed in cloning. At face value, it seems that the debates on scientific and technological issues require that the public, and sometimes the lawmakers, have expert knowledge of every innovation in every domain: an unrealistic expectation even for professional researchers.

Since such a target is obviously out of reach, it is crucial to define a sound scientific culture that would be sufficient for an informed decision on relevant social topics. The organization of a debate can thus be divided into two phases: an information phase and a participation phase. The information phase should include a description of the state of the art but also a clear statement of reasonable prospective horizons and their distinction from science-fiction, as well as an interrogation of the limits of that state of the art (uncertainties, lack of epidemiological and toxicological studies, etc.). We deal with these issues in the chapter on science education (see section 3.4); here we focus on other problems related to public engagement.

The organization of a debate on scientific and technological choices is a complex political problem. Participants will typically raise the following questions, which are well worth examining:

- Who are the debate organizers and how is their independence guaranteed?
- What are the selection criteria for speakers?
- How, and by whom, are questions chosen?
- If different topical sessions are organized, what is the justification of that division?
- How, and by whom, is speaking time distributed?
- What are the positions or preexisting intents of the institutions and individuals who take part in the debate? Is there any conflict of interest?
- What is the statistical representativity of the public? What are the sociocultural mechanisms determining exclusion from the debate?

[61] IPSOS, *Les Français et les sciences participatives*, http://www.ipsos.fr/sites/default/files/doc_associe/les-francais-et-les-sciences-participatives.pdf

[62] IPSOS, *Les Français et la science*, http://www.ipsos.fr/sites/default/files/attachments/les_francais_et_la_science.pdf

[63] IPSOS, *Les Français et les sciences participatives*, op. cit.

- What is the role of the media in reporting on the existence of the debate, its organization, its stakes and how it unfolds?
- Which sociocultural mechanisms contribute to the perception of the debate and its issues, as well as its constitution as a political question?
- If the debate has an official status and leads to recommendations, how and by whom are its results summarized and presented to decision-makers?

A discussion of these issues would be beyond the scope of the present report. It suffices to say that a clear awareness of their importance is necessary for the organization of a fruitful debate that would not be reduced to a simple acceptance mechanism.

If it is legitimate to question the organization of the debate, and to discuss the modalities of participation, it is more problematic that some try to stop the debate from happening at all. In the French context, it is not unusual that anti-technology groups adopt such an attitude and decide unilaterally the fate of a debate designed for the entire society. This phenomenon is detrimental to the inclusivity of the dialogue between science and society. While discussing the 2009-2010 national debate on nanotechnologies, the NANOCODE project[64] report states:

> "*In February 2009 the government through seven ministries and secretariats of state requested that a national debate on nanotechnology be organized by the National Public Debate Commission (CNDP), an independent body established under the French law. CNDP appointed a special commission to organize and run this debate (CPDP), which has planned 17 public debates in different French cities from September 2009 to February 2010. Only about a half of them took place, while others were cancelled or highly perturbed by anti-nano demonstrations. The main slogan of the demonstrators was that all the decisions have already been made and a public debate is useless and only serves as an acceptance mechanism for the society to come to terms with the choices already made by the government."* [65]

A similar scenario unfolded during the 2013 debate on synthetic biology organized by the CNAM on the initiative of the MENESR. Repeatedly blocking a debate, which is interrupted by force or reduced to a simple shouting match, prevents many scientists from participating. To debate scientific and technological issues, a careful choice of format is thus in order. Such a format must achieve a delicate balance between openness to criticism, including criticism on the form, organization or assumptions of the debate, and a defense against the interruption or manipulation of the debate by rogue groups. This represents a structural barrier in France, which has no one-size-fits-all solution: one needs a multifaceted, possibly decentralized, approach to public engagement.

[64] "NANOCODE is a European project funded under the 'Capacities' programme, in the area 'Science in society', within the Seventh Framework Programme (FP7). The objective of NANOCODE was to define and develop a framework (MasterPlan) aimed at improving and strengthening awareness and supporting the successful integration and wider implementation of the European Commission code of conduct (EC-CoC) for responsible Nanosciences and nanotechnologies (N&N) research at European level and beyond, integrated with an implementation assistance tool (CodeMeter)". Source: https://cordis.europa.eu/result/rcn/55409_en.html

[65] European Commission FP7 NanoCode projet, deliverable 1.1, May 2010.

Main drivers (structural, cultural or related to interchange dynamics)

Cultural mechanisms are essential to public engagement with scientific research. In everyday life, technological artefacts are often perceived as "black boxes" by their users: any activity reducing the magical appearance of science to non-specialists is of particular relevance.

There is a desire among citizens to have a first person experience of the researcher's work, which has translated into texts and actions from elected representatives. Opening up research institutions to society is now a necessity.

This need to participate and to demystify has not gone unnoticed institution-wise. To this end, institutions elaborate mechanisms and collaboration procedures with civil society. From a structural point of view, some institutions, such as those involved in biology and biotechnology (INRA, INSERM) have created missions for public engagement and participative science. Some other pilot examples in participative science have been put into practice by other institutions such as INRIA, CNRS and CEA.

Best practices

The largest European association in participative science, *La Paillasse*[66] (The Laboratory Bench) is located in Paris. Founded in 2009, this project was made an association in April 2011. It aimed at creating a biotechnology lab open to all citizens. Since then, *La Paillasse* has become a network of interdisciplinary labs which offers, without any discrimination based on age, education or revenue, a legal, technical and ethical framework for collaborative, open-source projects in biotechnologies and synthetic biology. The values of the association are the following:

- Rediscovering science in the era of collective intelligence to allow for a more open, distributed and cooperative science;
- Developing the use of *open data* and *open hardware* applied to science and technology;
- Encouraging experimentation, initiatives going against common intuitions, and citizen counter-powers;
- Making the lab accessible to explorers, scientists, entrepreneurs, creators and citizens willing to share their own vision of technology;
- Promoting science as a tool of social and environmental well-being through entrepreneurship.

After several successful years, *La Paillasse* has become an international exemplar, which inspired similar initiatives in the Philippines and Ireland.

[66] https://lapaillasse.org

4.5 Gender equality and diversity strategies in French research system

Description of current practice and its dynamics: review of its operation

In 2014, the proportion of women in research staff was equal to 30%. It is weaker in private R&D (22%) than in public research (42%). It is also weaker among researchers (26%) than among support staff (38%)[67]. Nevertheless, it is in constant progression since the early 2000s thanks to a generational change in scientific research personnel.

This proportion varies significantly with scientific disciplines. For instance, the proportion of women among researchers at the medical Pasteur Institute reaches 49.7%; the proportion in Literature and Social Sciences is 69.7%. In engineering, however, the proportion of female students falls to 27%; among researchers in "Electronic parts, electronic charts, computers and peripherals", it is a paltry 13.6%. Among larger research institutions, the proportion of women at CNRS is 34%, and 30.7% at the CEA (civilian branch) [68].

Main barriers (structural, cultural or related to interchange dynamics)

Certain cultural barriers influencing the choice of curricula are still very much present in the French society. Women represent less than 10% of historical characters in French schoolbooks, and there is virtually no mention of female contributions to the history of science[69]. While female students have better grades on average than male students at the end of middle school (*collège*), and are more likely to finish high school with honors if they specialized in science[70], there is significantly less female students in engineering curricula than in biology or medicine. According to a study published in 2017 by the NGO *Femmes ingénieurs (*"Engineer Women"*)*, two thirds of female students in engineering schools have considered changing their curriculum because of widespread ambient sexism[71].

This situation is in part an historical heritage of the exclusion of women from engineering schools. Taking some of the most prestigious engineering schools in France as an example, the entrance exam was only opened to women in 1962 for the *École Nationale des Ponts et Chaussées*[72], in 1969 for the *École des Mines*[73], and in 1972 for the *École Polytechnique*[74]. The exam for *École Centrale* was open in 1918, but less than ten slots were open for women until 1976[75]. However, the influence of gender on curricula choices is much deeper than this, and is felt much earlier: only 30% of female high school students choose to specialize in science, for

[67] https://publication.enseignementsup-recherche.gouv.fr/eesr/10/EESR10_RESUME-l_etat_de_l_enseignement_superieur_et_de_la_recherche_resume.php

[68] https://publication.enseignementsup-recherche.gouv.fr/eesr/10/chiffres_cles-3-N.php

[69] *Rapport fait au nom de la délégation aux droits des femmes et à l'égalité des chances entre les hommes et les femmes, sur les femmes et les sciences*, par M[me] Céline Calvez et M. Stéphane Viry, députés, p. 50 : http://www.assemblee-nationale.fr/15/pdf/rap-info/i1016.pdf Referenced henceforth as « Rapport Calvez-Viry ».

[70] Rapport Calvez-Viry, pp.12-14.

[71] Rapport Calvez-Viry, p.61.

[72] https://www.cairn.info/revue-carrefours-de-l-education-2004-1-page-58.html

[73] https://patrimoine.mines-paristech.fr/exhibits/show/mines_au_feminin/femmes_ingenieures_ecole_mine

[74] https://fr.wikipedia.org/wiki/Anne_Chopinet

[75] http://archives-histoire.centraliens.net/pdfs/revues/rev640.pdf

39% of male high school students[76]. If female students are a large majority in literary studies (80%), it's not so much because they would have a strong preference for this curriculum, but because of a strong deficit of male students, who are the majority in the science curriculum[77]. As Françoise Vouillot justly noticed[78], the absence of male students in health and care, literary and social science curricula is hardly a topic of debate, while it shows the depth of gendered structuration of professional roles, which goes much deeper than a simple mis- or under-information of female students.

Generational change is a long and slow process, and the increase of female presence in various curricula is very progressive[79]. After raising from 19,9% in 1990 to 27,8% in 2011, the rate of female students in engineering schools has been stagnating around 28% between 2012-2017[80]. Computer science is in a category of its own, since it is the only scientific curriculum where the percentage of female students has decreased in the last decades[81].

International examples have a very limited influence in France: there are no "affirmative action" measures in the French higher education and research system. Parity is a fundamental legal requirement, not preference.

It is very difficult to extend the gender approach to other discrimination factors, such as race, religion, or ethnicity: there are stringent legal restrictions on the collection and treatment of such data, commonly known as "prohibition of ethnic statistics." This stringent prohibition comes from the rejection of an historical counter-example: the Vichy government, which collected data on French Jews and Jewish foreigners to enforce its anti-Semitic policies. As a consequence, the January 6th 1978 Law known as "Informatics and Freedoms" (*Informatique et Libertés)* strictly forbids to collect and store data on anyone's "racial" or ethnic origins, as well as their confession. A couple permissions are granted, on case by case basis, by the National Commission on Informatics and Freedoms (*Commission Nationale Informatique et Libertés,* CNIL) when the data is collected, stored and treated only for research purposes. Any large-scale collection of ethnic statistics for administrative purposes, even in order to promote diversity in the workplace, is thus legally impossible.

Main drivers (structural, cultural or related to interchange dynamics)

Since recently, France has a strong regulation on parity in the upper echelons of academic and scientific governance (see section 1.2). Thanks to this new legal framework, the "Gender" key is the only RRI key endowed with numeric indicators at the national level.

[76] After their first year in high school (until the next academic year), students in general high school had to choose between three curricula, roughly corresponding to science, literary studies and social sciences.
[77] Rapport Calvez-Viry, p.17.
[78] Françoise Vouillot, « L'orientation aux prises avec le genre », in *Travail, genre et sociétés, n°18,* 2007 Quoted in Rapport Calvez-Virez, p.52.
[79] For more details, see *Mission pour la place des femmes au CNRS* http://www.cnrs.fr/mpdf/
[80] https://www.orientation-education.com/article/la-part-de-femmes-dans-les-ecoles-d-ingenieurs-n-augmente-plus
[81] Rapport Calvez-Viry, p.11 : http://www.assemblee-nationale.fr/15/pdf/rap-info/i1016.pdf

From a cultural viewpoint, the French society is now used to react vigorously when parity is not respected. This happens at all levels, including research governance. An ethics committee without parity would be hardly conceivable at the national level. This political and media pressure is a considerable factor in the enforcement of gender equality.

Best practices

In research institutions, the Mission for women's integration at CNRS (*Mission pour la place des femmes au CNRS*) is undoubtedly a remarkable example both at national and European levels. Founded in 2001, it reports directly to the President of the CNRS, and is in charge of initiating, coordinating, supporting and reviewing gender-based actions in the CNRS global policies. It played a major role in the elaboration of the Action plan for professional gender equality (*Plan d'action pour l'égalité professionnelle Femmes*-Hommes) at CNRS, which was adopted in 2014. It was thanks to this mission that the CNRS obtained the European label "*HR Excellence in Research"* (HRS4R) in February 2017.

The mission works simultaneously on four major themes: working for professional gender equality, promoting the transversality of research on this subject, promoting scientific careers with young women and female role models, developing French, European and international partnerships. Its action plan can also be presented along four axes: involving leaders, acting on the organizational structure, acting on career progression and promoting work-life balance. As a key action, we should mention the training on equality and social gender stereotypes for leaders which has been put in place since 2011. A dedicated working group, the STRIDE Committee ("Strategies and Tactics for Recruiting to Increase Diversity and Excellence") examines the possible sources of gender inequality in the scientific evaluation process and formulates recommendations aimed at improving the procedures for recruitment, promotion and awarding distinctions to research personnel at the CNRS. CNRS has also been a pioneer in France at integrating the gender dimension in research projects beyond social and human sciences alone, in particular through the Gender Challenge Program (*Défi Genre*)[82].

Such a dedicated mission, even if it is demanding in resources, remains an effective tool to implement a genuine gender equality policy and to reach ambitious targets in the medium term.

4.6 Open access and open science strategies in the French scientific system

Description of current practice and its dynamics: review of its operation

In France, open access to scientific publications relies essentially on research institutions and the European level. Until recently, very few initiatives came from national authorities. The July 22nd 2013 law on research introduced among the goals of public research the "sharing and dissemination of scientific knowledge, giving priority to open access formats" and the "organization of open access to scientific data" (cf article L.112-1 of the *Code de la Recherche*).

[82] This paragraph is a brief summary of the presentation of the Mission in the CNRS *Human Resources Strategy for Researchers*, which is available at http://www.cnrs.fr/en/science-news/docs/HRS4R-en.pdf

On April 2nd, 2013, at the Academy of Sciences, several institutions signed a "Partnership agreement for open archives and the shared portal HAL" (*Convention de partenariat en faveur des archives ouvertes et de la plateforme mutualisée HAL*[83]). This led to the creation of the first French portal for the deposit of scientific publications. Institutional portals (e.g. at INRA) must be integrated to HAL within several years, which will make it the sole such shared portal in France.

Since 2016, the Law for a Digital Republic (*Loi pour une République numérique*) facilitates deposit in open archives and defines a new exception to intellectual property rights, which allows for mining data or text included in, or associated with, scientific publications.

The *Club des Organismes de Recherche Associés* ("Club of Associated Research Institutions", CLORA) was created to facilitate the interaction of French public research organizations with European institutions in research, technology, innovation, and training. It then created a dedicated group on open access. This forum enables better policy coordination with the goal of making the French voice heard at the European level. In view of the absence of leadership on this issue, CLORA plays a central role in the implementation of open access policies in France.

In late 2017, the French government committed to "building an ecosystem of Open science"[84] as a part of the Open Government Partnership (OGP[85]) roadmap. In this ecosystem, science will be more transparent, fast-tracked, and easily accessible. This commitment from the Government results in a more democratic access to knowledge, which is useful for research, training and society, and constitutes an opportunity for participative science. The year 2018 saw a clear commitment to open access by the Ministry of Higher Education, Research and Innovation (*Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation,* MENSER) through the creation of the Committee for Open Science (*Comité pour la science ouverte*, CoSO). Open science should foster scientific advances, particularly unexpected advances, as well as economic and social progress.

There is no national coordination of policies regarding research data. The level of activity varies greatly among institutions. For instance, the INIST at CNRS provides a set of online tools and services (OPIDoR, DoRANum, DataCite, tutorials…) related to research data[86].

Main barriers (structural, cultural or related to interchange dynamics)

In the absence of a clear national policy for open access to scientific publications, institutions are free to determine their own strategy. As the creation of HAL demonstrates, a certain amount of coordination exists nevertheless but remains deeply insufficient. HAL is structured by institution: each of them is responsible for the open access deposit of its own publications. Sharing human and documentary resources faces important difficulties and varies greatly from institution to institution.

[83] https://hal.archives-ouvertes.fr/

[84] https://gouvernement-ouvert.etalab.gouv.fr/pgo-concertation/topic/5a1bfc1b498edd6b29cb10d4

[85] https://www.opengovpartnership.org

[86] http://www.inist.fr/

From a cultural point of view, the barriers to open access in France are similar to the barriers seen in the rest of the world. Most renowned scientific reviews are private property of large publishing corporations. As a consequence, an open access publication in a prestigious review, the Gold Open Access model, demands an extra financial effort from the scientific institution. This funding adds to the cost of subscriptions. It is clear that such a transitional state between two models of scientific publication is unsustainable. Among recent illustrations of those difficulties, the recent negotiations between Springer and the COUPERIN consortium, which counts the CNRS as one of its members, ended on a note of disagreement. The consortium protested against the expected augmentation of Springer reviews subscriptions, even as the open access of numerous articles in those same reviews have already been paid for[87]. This ongoing conflict is part of a series of similar incidents at the international level, such as the boycott campaign against Elsevier launched by the mathematician Tim Gower[88], which lead to the movement *The Cost of Knowledge*[89], or the abandonment of most of its Springer subscriptions by the University of Montréal in 2016[90].

The Green Open Access model, which consists in the deposit of a published or unpublished article in an open archive, suffers from embargoes imposed by publishers, which diminishes its visibility.

Main drivers (structural, cultural or related to interchange dynamics)

The European program H2020 made open access publication of scientific papers mandatory, provided they are product of a research project funded by the European commission[91]. This requirement gave a strong impulse to the dissemination of open access publication practices. It also attracted the researchers' attention to this issue. It would not be an overstatement to say that that structural coercive measure had a more significant impact than the rest of cultural factors or awareness-raising measures.

In the framework of the H2020 European projects, the Data Management Plan (DMP) is mandatory, and the open access deposit of data is recommended, and even mandatory for a project part of the pilot H2020 Open Research Data[92]. Again, this demand is a strong incentive for researchers to think of the merits of Open Data, and to build a genuine data management and preservation plan.

[87] http://www.cnrs.fr/inshs/recherche/springer.htm
[88] https://gowers.wordpress.com/2012/01/21/elsevier-my-part-in-its-downfall/
[89] http://thecostofknowledge.com/
[90] http://www.bib.umontreal.ca/communiques/20160505-DC-annulation-springer.htm
[91] Article 29.2 of the Model Grant Agreement of H2020 Program.
[92] H2020 Program - Guidelines on Fair Data Management in Horizon 2020. European Commission, July 2016: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf

Best practices

Since October 2015, French public research organization INRIA, which is specialized in computer science, has evaluated its researchers and teams based only on open-access publications deposited in HAL. A generalization of this practice could make HAL a truly popular open scientific library at the national level.

The Government has defined the French ambition for open science in the following fashion:

> Building an ecosystem of "Open Science."
>
> In France, the progress made in open science is highly different according to disciplines, actors, institutions, and territories. The 2016 Digital Republic law has spurred a great advance in this domain, through dispositions promoting open access and text and data mining (TDM).
>
> There is still a lot to be done, for open science to take its rightful place in scientific practices.

The Government proposes the following road map:

- Creation of a "Committee for Open Science" for open exchange, both at national and international levels, on issues related to Open Science (Access, data, metrics, codes, participative science) (2018).
- Implementing a quantitative monitoring of open access dissemination in national scientific literature (2019).
- Implementing a fast and transparent monitoring for expenses relative to article processing charges and book processing charges (2020).
- Implementing a transparent, public monitoring for expenses relative to electronic acquisitions in academic libraries. Publication of expenses in open data on the MESRI open data platform (ERE investigation[93]) (2018).
- Producing an open dataset on research project funding through calls for projects and their beneficiaries (2019).
- National subscription to ORCID (individual identification system for researchers, allowing for a faster and safer recognition of a researcher's scientific contributions) – (2018 or 2019).
- Acceleration of the development of the national open archive HAL with an focus on user experience simplicity and interoperability (ongoing funding 2018-2020).
- Strengthening scanR, research engine for research and innovation, developing awareness and use of this instrument, in particular for feeding public debates on research products (ongoing funding 2018-2020).

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93 The Investigation on Electronic Resources (*Enquête sur les Ressources Électroniques*) was led by the Ministry of Higher Education, Research and Innovation (MESRI) and the Couperin Consortium to build a database on electronic bibliographic resources in higher education and research. Its results are available on the Couperin website www.couperin.org

— Communicate with scientific communities on the implications of the Digital Republic law relative to open access publication and open data (2018 or 2019).
— In the framework of public support to reviews, recommend the adoption of open data policies for their papers and the development of data papers.
— Progressive universal implementation of data management plans in calls for projects via support and incentives for open data (ongoing funding, 2019).

4.7 Science education as integrated in research

Description of current practice and its dynamics: review of its operation

Science education is acknowledged as an activity of utmost importance for the French Republic. The national strategy for research defines it as a priority: "To address societal issues, knowledge must not only be produced, but integrated in our practices and our societies, in our curricula, in initial as well as in continuing training."

In early 2017, the *Assemblée Nationale* reaffirmed that priority in its Resolution on sciences and progress in the Republic. In particular, the Assembly:

— Suggests that introduction to science in elementary school be considerably reinforced in order to increase young students' awareness of scientific method;
— Invites the Government to monitor the quality of scientific courses in middle and high school. As a matter of fact, recent trends seem alarming;
— Wishes that the Government follow the recommendations of the Academy of Science, the Academy of Technologies and the Academy of Moral and Political Sciences, and encourage a greater interaction between science & engineering courses and social science as early as the last three years of high school, as well as in the rest of scientific curricula (and vice versa);
— Invites particularly the Government to strengthen the part of philosophy curriculum in high school and higher education dedicated to science and epistemology. In the current situation, only students in literature study the chapters on life, theory and experience. Such developments would be highly profitable for everyone, and particularly for science students who would acquire more epistemological knowledge on scientific practices and science-society relations;
— Invites the Government to reflect on pedagogical practices founded on a reasonable use of digital technologies, in particular teaching to sort information. This would facilitate a distinction between rigorously demonstrated knowledge and opinions without any scientific foundation;

All research organizations in France are involved in science education through actions towards teachers, high school students, middle school and sometimes primary school students, as well as the general public. Those actions are mainly concentrated in regions with a strong scientific potential, such as Île-de-France, Auvergne-Rhône-Alpes, Occitanie or Nouvelle Aquitaine.

They are typically led by dedicated missions or departments within research institutions, as for instance the Youth Education Service (*Service Éducation Jeunesse*) at CNES[94].

Every year, the Ministry of National Education implements training actions at the national level. Some of them are led by scientific actors. Furthermore, some administrative arrangements are implemented to foster scientific vocations such as *Sciences à l'école*, the *Fondation C'Génial* or *Faites de la science* organized by CDUS (Conference of the Directors of Scientific UFR[95]).

Main barriers (structural, cultural or related to interchange dynamics)

Research organizations propose various teaching actions. There is little coordination at the national level or between the institutions. Such actions, even if they take place on a regular basis, remain one-off by nature: their global impact on society is hard to measure.

Main drivers (structural, cultural or related to interchange dynamics)

There is a great number of well-established forces promoting science education in the French society. Curiosity and interest in science are very much present, and they represent a major cultural factor. The existence of departments dedicated to science education within research institutions facilitates the implementation of education actions. However, exchanges between institutions on this topic remain rare.

Best practices

In order to perpetuate science education actions, a collaboration between regional *academies* and, more generally, between actors of national education is very much needed. This collaboration could take multiple forms. For instance, since 25 years the *Centre National d'Études Spatiales* ("National Center for Space Studies", CNES[96]) has created a partnership with the ministry of National Education. In coordination with the General Inspection[97] in charge of school curricula, a great number of multidisciplinary educational projects on spatial exploration are proposed to teachers, from primary schools to higher education. As another example, the Service of curricula coordination (*Service de coordination des programmes*) GIANT at CEA/Grenoble[98] collaborates since 2009 with the rectorate[99] and develops methodologies to insert scientific content into national education curricula. Those pedagogical

[94] https://enseignants-mediateurs.cnes.fr/

[95] In the French higher education administrative system, a UFR (*Unité de Formation et de Recherche*) is a training and research department within a public university.

[96] https://cnes.fr/en

[97] In France, the General Inspection is the national administrative body in charge of monitoring teachers and school curricula in secondary education.

[98] https://www.minatec.org/fr/education/nanoschool/enseignants-et-lyceens/

[99] In France, the *rectorat* (rectorate) is the direction of the regional administrative district of the Ministry of National Education called an *academie.*

and methodological tools have enabled the Nano@School program[100] to reach out to the integrality of high school classes in the *département*[101]. They could be generalized to the entire territory.

4.8 Incorporation of AIRR dimensions into science policy debates

Participants of the National Seminar, as well as stakeholders interviewed during the preparation of this report, unanimously felt that RRI dimensions are present through RRI keys, and that on their own RRI dimensions are less clear and concrete than the keys. As a consequence, all data is reported through the keys. However, certain general trends were clearly perceptible:

Main barriers:

1. Feeling of being accused: "Do you mean that we weren't responsible before RRI?";
2. Fear of relativism;
3. Fear of losing research autonomy;
4. Fear of "RRI washing": simple rebranding of existing activities and structures with a RRI terminology as an acceptance mechanism, without any substantial reform or reflection.

Main drivers:

1. Inclusion of RRI activities, such as open access deposit, in the evaluation of researchers;
2. Imposition of strict conditions by H2020 funding;
3. Growing societal demand.

4.9 Integrated or fragmented nature of responsibility

Very few official documents mention different RRI keys on the same page, and none mentions RRI dimensions. In practice, French research does not perceive RRI as a unified phenomenon. There are multiple concrete actions focused on one or two related RRI keys, for instance, science education and public engagement.

There exist rare examples of political documents, such as the February 21st 2017 Resolution of the National Assembly on science and progress (*Résolution de l'Assemblée nationale sur les sciences et le progrès dans la République du 21 février 2017*), in which several RRI axes are mentioned side by side, but without any explicit mention of the European RRI concept.

In the French political context, the concept of sustainable development is one the most important approaches to scientific and technological responsibility. Sustainable development

[100] http://www.nanoatschool.org/

[101] In the French administrative system, the *département* is a mid-level territorial division, roughly equivalent in size to the county in Great-Britain.

thinking can be applied to any RRI key related issues, so it is also the only concept which provides an integrated approach of RRI keys.

A sustainable development model depends crucially on the choice of energy strategy, which is at the core of the CEA expertise (see section 3.1 below). After the quick rise of oil prices in the 1970s, in order to preserve its energetic independence, and promote its own industrial sector, France has made the choice of a nuclear-based strategy for its energy production. Today, 77% of the electric power consumed in the country is nuclear[102].

This original energy strategy is of course the topic of a political debate on sustainable development: while its defenders praise nuclear power for being carbon-free, its detractors criticize nuclear power for safety reasons, and its production of durable radioactive waste. Such a debate illustrates the heterogeneity of factors involved in sustainable development choices, raising deep ponderation issues: financial cost, safety of nuclear plants, waste management, toxicological risks, greenhouse gas emissions, energetic independence, etc. It also dictates a prospective vision of technological evolutions, and research investment priorities. A sustainable development model should at the very least satisfy the greenhouse gas emission reduction targets set by the Paris climate agreement and offer a sustainable, cost-effective energy production.

If sustainable energy production remains a desirable goal, its growth still raises issues of time and research efforts needed to build new infrastructures and of instability and intermittency of solar and wind power production. A fast transition out of nuclear power could only be achieved through a quick switch to thermal power plants, increasing the consumption of fossil fuels (gas, oil, coal) and consequently pushing the Paris agreement targets out of reach. Nuclear power is bound to play a role in the French energy mix in the medium term.

However the French energy strategy may evolve, the treatment of already produced nuclear waste is a major challenge for any conception of sustainable development. Nuclear waste might be one of the most durable artefacts created by our civilization. If geological storage is a consensual solution among experts, its implementation raises political issues. Beyond the difficulties caused by a choice of storage site, the time scale on which nuclear waste represents a toxicological risk is beyond any historical institutional framework, and represents an unprecedented challenge. It would be unthinkable to delegate this problem to the future generations: a responsible conception of technological waste management cannot be grounded on procrastination, even if that procrastination is excused by the expectation of hypothetical future innovations. Geological storage of nuclear waste is not only an issue for our future: it is also, and most importantly, a technological issue for the present. France, especially through the CEA, has developed a relevant expertise for this challenge, in particular in nuclear waste management, which allows for a diminution of its volume and radiotoxicity.

The notion of sustainable development accommodates these issues, which are excluded from the concept of RRI.

[102] https://www.edf.fr/groupe-edf/espaces-dedies/l-energie-de-a-a-z/tout-sur-l-energie/produire-de-l-electricite/le-nucleaire-en-chiffres

5. Aspects of responsibility in CEA policy and practice

5.1 Mapping of the organization

This report was written by CEA personnel, who have a long internal experience of CEA operations. As a consequence, no systematic methodology was applied to the sampling of documents or interviewees: expert knowledge and in-depth experience of the institutions were used to conduct the study.

5.2 CEA missions

The Alternative Energies and Atomic Energy Commission (*Commissariat à l'énergie atomique et aux énergies alternatives*, CEA) is a public research institution. In terms of workforce, it gathers 16,000 employees, the second largest number in French research after CNRS. CEA is located on nine sites across the country, and develops partnerships with other research institutions, local government and universities. It is a member of national alliances coordinating French research in energy (ANCRE), life and health sciences (Aviesan), digital sciences and technologies (Allistene), environmental sciences (AllEnvi) and social sciences (ATHENA).

CEA was created on October 18th 1945, just after World War II, with a very specific mission: "to pursue scientific and technical research in order to use atomic energy in various fields of science, industry and national defense." If the ordinance[103] creating CEA seems to circumscribe its action to a relatively limited field, its activity has been de facto extremely varied. The control of atomic energy necessitated numerous fundamental investigations in physics, chemistry and also biology to understand the effects of radioactivity on live organisms, and exploit them for medical purposes (diagnosis technics, radiotherapy).

Technological research is also at the core of CEA missions. The conception of electronuclear devices presupposed the development of expertise in electronics, computer science or robotics. In a context where reliability is key, CEA has developed in-depth knowledge and expertise, which sparked the interest of other actors in other fields. As an example, radiation detection methods turned out to have unexpected applications in many other fields, especially in earth and climate sciences or astrophysics.

Initially, CEA meant "Atomic Energy Commission". But in 2010, at the initiative of the government, CEA was rebranded to become "Alternative Energies and Atomic Energy Commission". Today, research on renewable energies is a full part of CEA missions.

In 2016, its tasks have been clarified and completed by decree (n° 2016-311, March 17th 2016 relative to the organization and operation of the Alternative Energies and Atomic Energy

[103] Amended several times, it is now part of the code for the environment (*code de l'environnement*, articles L. 332-1 et seq.).

Commission). CEA is now structured around four great tasks:

- National Defense Task: CEA is responsible for the French nuclear deterrence. It contributes to national and international security through the technical support it brings to the authorities on nuclear proliferation and terrorism issues, as well as decommissioning;
- Nuclear Task: CEA contributes to the competitiveness of the nuclear industrial sector, especially through the implementation of a sustainable nuclear power, and to the reinforcement of its safety. It develops an R&D program on civil nuclear reactors and nuclear fuel life cycle. This program includes the optimization of existing nuclear technologies, the development of the next generation of nuclear plants, the study of their impact on health, environment, as well as the decommissioning of nuclear power plants;
- Technology development and transfer Task: CEA takes part in the industrial recovery of the country through the exploitation and transfer of skills, knowledge and the dissemination of technologies in the industry. Renewable energies technologies, information technologies and health technologies are all part of that field. Furthermore, CEA brings its support to the scientific communities using large scientific equipment thanks to its expertise in technological development (particle colliders, cryotechnologies, instruments for physics and fundamental chemistry);
- Fundamental research task: through the fundamental research that it develops, CEA contributes to our nation's scientific reputation, to scientific progress, to the conception and operation of great research infrastructures for the benefit of the scientific community. This fundamental research task is meant to feed other tasks with breakthrough innovations, and ensure the continuity of skills necessary to their realization. Its field of enquiry includes the following areas: biology, genomics, astrophysics, theoretical physics and modelling. Furthermore, thanks to its expertise in radiation physics, CEA leads a world-class research in the fields of astrophysics, and earth and climate sciences.

5.3 CEA organization

CEA organization and legal status have been conceived in accordance with its particular tasks. In the presentation of the motivations for its creation, it has been made explicit that CEA is an establishment which is "very close to the government, and so to speak intertwined with it." It was initially put under the authority of the Prime Ministry, and is placed today under the tutelage of four Ministries: Energy, Research, Industry, and Defense. A pluriannual performance agreement is signed between the State and CEA: it determines the strategic orientations of its civil activities for the relevant period, and defines the implementation of those orientations within the state budgetary framework. This agreement specifies several benchmarks and indicators which are reviewed every year by the Executive Board (*Conseil d'Administration*), where all parent Ministries are represented.

CEA enjoys a particular status as a public scientific, technological and industrial establishment. It is the only one of its kind in France. As a public establishment, its activities are closely circumscribed by the government policy in its fields of intervention; but in terms of management it enjoys a "great freedom of action", as desired by its "founding fathers": they conceived that freedom as a sine qua non condition of its effectiveness. This unique status positions the institution halfway between two models described by J. Habermas[104]: the model he called "decisionist" in line with J.-J. Rousseau and Max Weber, where the scientist executes a policy initiated by political power, and the "technocratic" model, where, in line with H. Arendt[105], knowledge is power and makes the engineer a true master of society.

After consulting with the economy and finance commission of both parliamentary chambers[106], the President of the Republic names by decree a "Administrator General" (*Administrateur Général*, AG), who runs the general direction of the establishment. It is customary that the Administrator General be also named president of the supervisory board.

The President of the Republic also names by decree a "High Commissioner for Atomic Energy" (*Haut-Commissaire à l'énergie atomique,* HC), who assumes the function of senior scientific and technological advisor to the AG. This independent personality enjoys a unique status, because she is not a de facto member of CEA but is closely associated to its most strategic administrative bodies. At the request of the AG or a Ministry, she can be in charge of various advice and expertise missions in the CEA fields of intervention, as well as other missions for national defense and education. She can also submit propositions relative to the general scientific and technological orientations to the relevant Ministries.

In order to fulfill its missions, CEA is organized in four operational[107] divisions: the Military Applications Division, the Nuclear Energy Division, the Fundamental Research Division, and the Technological Research Division. Under the authority of the General Division, operational divisions determine the strategic orientations and missions in their field of competence, define the programs and the means necessary to their realization, and review their proper implementation.

Those divisions rely on functional divisions with specific field of competence: Human Resources and Social Relations, Nuclear Safety and Security, Finance, Legal Affairs, International Relations, Strategic Analysis, Information Systems, Communication, Strategic Partnerships and Sales.

For any study of RRI in the French context, CEA is both an original and essential case study.

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[104] J. Habermas, *Toward a Rational Society. Student protest, Science and Politics.* Jeremy J. Shapiro (transl.), Beacon, 1969.

[105] H. Arendt, *Human Condition*, Chicago: University of Chicago Press, 1958.

[106] France has a bicameral parliamentary system: the lower chamber is the *Assemblée nationale,* which is directly elected, and the upper chamber is the *Sénat,* which is indirectly elected.

[107] In CEA nomenclature, an operational division carries out a technological or scientific task; a functional division carries out administrative tasks. For a complete view of the organization chart, see http://www.cea.fr/english/Documents/organization-chart.pdf

CEA is original because of its history, the national defense orientation of part of its activity, and its unique position in the organization chart of French research, formalized by a particular status. CEA is also essential because of its size, and because of its implication in high strategic value research fields, especially in energy, which are relevant for the deepest relations between science, technology and society. All those factors contribute in making CEA a particularly interesting case study, but also a difficult one because of the sensitivity of addressed issues.

5.4 The conceptualizations of responsibility at CEA

The notion of responsibility occurs only once in the revised March 17th, 2016, CEA decree. But its occurrence is far from being insignificant: it is part of a reminder of CEA responsibility in the implementation of nuclear weapons programs.

As mentioned above, CEA was created at the end of World War II to enable France to master atomic energy. The ordinance founding CEA was enacted on October 18th 1945, a couple weeks after the explosion of two atomic bombs on Hiroshima and Nagasaki. The creation of CEA was already in the pipeline before that event, in order to restart the research by Nobel Prize winners Frédéric Joliot and Irène Curie, which was interrupted by the war. But the actual use of nuclear weapons radically modified the relation between humanity and science and technology. The government and the researchers were indeed very much aware of their responsibility. The ordinance creating CEA defines its mission as nuclear energy research. But it immediately stipulates that the institution mission is also to prevent potential detrimental effects of its own subject matter, since CEA was in charge of studying "the measures necessary to ensure the protection of persons and goods against the destructive effects of atomic energy."

The double nature of the CEA researches is made explicit in the interventions of the High Commissioner and Administrator General of that time. The first AG Raoul Dautry declared: "It is now important to restart the effort which was everywhere interrupted in front of war necessities, and to work in order to master atomic energy for works of peace, not death. I am convinced that French science will take a large part in that beautiful human task." Frédéric Jolio-Curie, Nobel Prize winner and first High Commissioner declared in the communist newspaper *L'Humanité*: "From a personal point of view, I am convinced that despite the feelings caused by the application of atomic energy to destructive ends, this energy will deliver priceless services in peace."

In 2010, a thorough work was conducted by CEA in order to define the values which should guide its action. It was purely internal, and was not given any publicity: its sole aim was to lead a reflection inside the institution to define guidelines for researchers. Six basic values have been identified. A survey carried among CEA employees revealed that in more than 80% of answers, the first quoted value was the sense of public interest. This is the value put in first place by CEA in its internal documents: "Carved into the genes of CEA by the 1945 Ordinance, its sense of public interest guides it in the answers it gives to great societal issues. It is incumbent upon us to anticipate society's needs with the necessary pragmatism and distance; to support the

sustainability of our vision; to answer without dogmatism to the controversies sparked by those issues."

The second value is precisely that of responsibility: "CEA responsibility rests on our will to be held accountable of our actions and their consequences; whether it is to acknowledge the past, face the present or anticipate the future. Our past actions and our reliability support our credibility, and attest to our ability to meet challenges and carry actions in the long run."

CEA also underlines social engagement as one of its founding value: "The social engagement of CEA relies on strong convictions and translates into our ability to be a proactive source of proposals in a sensitive environment. Our team spirit allows us to bring the best out of our various fields of competence, and to bring forth innovative projects. CEA realizations show the tenacity necessary to develop ambitious projects on a timescale involving several generations." In various communications, CEA shows its sharp awareness of the long term consequences of its actions.

The last values are exigency, a taste for complexity and solidarity. As a matter of fact, there are important variations among the 16,000 CEA employees, especially from one operational division to another. The Fundamental Research Division is very open on the outside world and the general public, with various collaborations with other national and international research institutions; on the other end, the activities of the Military Applications Division are, by essence and necessity, under the protection of defense secrecy: practices, motivations, interests can thus be extremely different.

A general point of improvement: considering its missions and the various cultures existing within its operational divisions, CEA communicates very little, or not at all, on the limitations of scientific knowledge, and the intrinsic uncertainty of knowledge research. It seems necessary to have a reflection on this topic, in order to define the needs and modalities of a more inclusive institutional communication strategy, which would include this dimension of uncertainty.

Key Performance Indicator of the CEA RRI policy: the scientist's acquisition of knowledge is and must remain free, whatever the evolution of the scientific work environment may be, especially after the introduction of the RRI notions and the ensuing actions. This does not imply that ethical reflection might be neglected.

5.5 Science education as integrated in research

In 2003, willing to fight against the disaffection of high school graduates for scientific studies, Prime Minister Jean-Pierre Raffarin decided to add an official task of pedagogical action to CEA missions. Thus CEA, a research organization, was charged with the dissemination of scientific, technological and industrial culture. Internally, the Administrator General attributed this task to the Communication Department.

Within one year, CEA developed a network of "correspondents for pedagogical action" (reference officers) at centers, *Institut National des Sciences et Techniques Nucléaires* (National Institute of Nuclear Sciences and Technologies, INSTN), and the HR Division. In 2016, several institutes and laboratories[108] joined the pedagogical action network, bringing the total number of correspondents to 24. The network of pedagogical action correspondents meets several times a year to define its strategy and actions to be implemented, to exchange best practices and coordinate concrete actions.

The network, based on voluntary measures, operates across institutes and divisions. Its activities are not ordered top-down, but they originate from a multitude of bottom-up local initiatives. An annual audit of network activities has been held since 2012, showing over 1,000 CEA personnel involved. Yet even this number is probably underestimated, for network correspondents regularly discover previously unaccounted local activities (school visits, participations to job fairs, publications…).

The network does not offer a formalized methodology to address the general public; however, there exists a two-day training session "Communicating science", with two session per year each intended for 10 people. This training is divided in two parts. The first, conducted by an actress, aims to initiate scientists to a simple public speaking exercise, on the model of *Ma thèse en 180 secondes*[109]. The second, conducted by the NGO *Planète Sciences*[110], teaches how to set up a demo of a scientific experiment.

The shock of the 2015 terrorist attacks triggered two reactions in the network. The first was a push for critical thinking through the dissemination of scientific culture, in order to fight against propagation of rumors and plot theories, especially among school children. The second was to participate to the fight against the cultural and economic marginalization of low-income neighborhoods, through the *Science for everyone* action (see below the "Internship *Science pour tous*" section). This fight is now an official objective of the President of the Republic[111]. As a consequence, this action is now part of a broader political framework, and the dissemination of scientific, technological and industrial culture is an integral part of CEA corporate social responsibility.

There might exist a partial overlap between the activities of the pedagogical mission and the ambition to develop a CEA employer brand, launched in 2017 by the HR Division willing to raise the attractiveness of CEA among science students. This new project complements the pedagogical mission, which is mainly directed at primary and high school students but only occasionally addresses university students.

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[108] *Institut de Recherche sur les lois Fondamentales de l'Univers,* Research Institute on the Fundamental Laws of the Universe, (IRFU), ITER France (Nuclear Fusion Experiment), *Centre National de Recherche sur le Génome Humain,* National Research Center on Human Genome, (CNRGH), *Laboratoire Science Climat et Environnement*, Climate & Environment Science Laboratory, (LSCE), Minatec, Visiatome.

[109] *Ma thèse en 180 secondes* ("My dissertation in 180 seconds") is a science education initiative where a PhD candidate has to explain the topic of her dissertation to a profane audience in 180 seconds: http://mt180.fr/

[110] https://www.planete-sciences.org/national/

[111] http://www.elysee.fr/declarations/article/discours-du-president-de-la-republique-la-france-une-chance-pour-chacun/

For CEA[112], the dissemination of scientific knowledge towards the youth, teachers and the general public is a key part of its public service mission. In this regard, every action, tool and publication set forth by CEA is completely free. CEA has set three priorities for this mission:

- "Promoting science and technology": this is a communication target;
- "Making research career paths known to the youth": the target, as mentioned above, is to attract future students to ensure the existence of a sustainable pool of scientists;
- "Providing to citizens food for thought on great social issues": this third mission is of course related to the notion of public engagement. CEA is very much aware of addressing numerous social issues through its research: energy, climate, health, environment, new technologies… As indicated by its baseline, "From research to industry", CEA is at the core of yesterday's and tomorrow's innovations. That is a key point, which is often put forward during the introduction of its presentations to the general public.
- "Helping the youth to develop critical thinking": this fourth mission does not occur in the 2012 document, but it was presented during the RRI-Practice national workshop on February 24th, 2017.

From 2012 to the end of 2017, the Direction of communication relied on the competences of a certificated physics and chemistry teacher to ensure the adequacy between various CEA productions (publications, educational activities, practical exercises) and the expectations of school teachers.

CEA has implemented numerous actions in order to reach out to a large audience (students, teachers, general public, families). In 2017, no less than 27,900 teachers and students from primary, middle and high school[113] level have benefited from those actions: educational workshops, visits, demonstrations, conferences, training sessions, fora, presentations on career development… It also proposes tools and materials accessible to all.

Educational publications

CEA publishes several magazines for the general public: their level of outreach is adapted to a quite large audience more or less familiar with technical and scientific culture. The magazine *Les clefs (*"Keys"*)* provides updates on most important CEA research topics and on cross-cutting themes. It reaches out to a scientifically trained audience who wish to learn about latest results obtained in CEA laboratories. The magazine *Les Défis (Challenges)* reaches out to a larger audience with an interest in sciences, which may lack scientific training. It offers a monthly thematic dossier on the CEA research and its applications, reveals latest scientific

[112]This was an answer to an invitation of the Parliamentary Office for Scientific and Technological Assessment (*Office parlementaire d'évaluation des choix scientifiques et technologiques*), which in 2012 contacted all research institutions to have their vision of the dissemination of scientific and technical culture, and to better understand their actions in this field.

[113] In France, the compulsory school system is divided into primary school (*école primaire,* from age 6 to 11), middle school (*collège,* 11 to 15) and high school (*lycée,* 16 to 18).

results of the month and provides educational infography ("*Tout s'explique", That explains everything*). Furthermore, CEA publishes a magazine (4 issues per school year) for middle and high school students, called "Les *Savanturiers*", which sheds light in a simple and playful manner on those who, in their lab or in the field, work and explore the world to move knowledge forward. Finally, CEA publishes a collection of "educational booklets" (*Livrets pédagogiques*) with associated quizzes, in order to provide a first sense of important scientific concepts.

A large part of the CEA institutional website is dedicated to scientific mediation and educational actions, particularly a space dedicated to youth and a teachers' space with specific resources. More than a hundred videos are accessible to understand basic scientific notions, created thanks to a partnership with the broadcaster *Esprit sorcier,* successor of a popular science TV show *C'est pas sorcier* ("This isn't rocket science") and its famous host Fred Courant. CEA has also opened three Youtube channels gathering more than 23,000 thousand followers. The scientific mediation conferences *Cyclopes* organized by the CEA/Paris Saclay center are accessible online. They take place 4 times a year with an average on-site audience of 300 people. On the Web some conferences reach more than 75,000 views.

Other educational tools

On top of its specific publications or cultural animations, the Communication Department produces all CEA educational resources. One can mention the travelling exhibitions *Voyage au centre de la galaxie* (A Journey to the Core of the Galaxy), *Amazing Science*, *Science Machina*, *L'Odyssée de la lumière* (The Odyssey of Light), *Au cœur de l'énergie* (At the Core of Energy), etc., but also webdocumentaries on climate and on the Odyssey of light. For instance, CEA has worked with physics, chemistry, life and earth sciences and French literature teachers to conceive a role game, *Défi Energie* ("Energy Challenge"), about energy transition for students in the final year of middle school. This large panels of educational tools is freely accessible on the website teachers' space[114].

Reception spaces for school visits and the general public

On top of those virtual spaces, CEA has created reception spaces for the public at its various centers, in order to disseminate knowledge on the research activities happening inside those centers. For instance, CEA took the initiative to build a scientific and recreational space next to one of its sites, in Marcoule in Southern France. This site, named *Visiatome*, helps visitors to discover fundamental issues on nuclear energy, radioactivity, or nuclear waste in a permanent museographic space. With its temporary exhibitions and conferences on many scientific topics, it has become a major cultural attraction in the region, with more than 20,000 visitors a year. From primary school to the end of high school, many classes visit *Visiatome* all year long.

[114] http://www.cea.fr/comprendre/enseignants/Pages/ressources-pedagogiques.aspx

Students can have a first-person experience of a scientific experiment on the bench, with topics ranging from drinkable water to perfume chemistry, bioluminescence and states of matter, etc.

At the Fontenay-aux-Roses (FAR) site, *Infodem* is an information space offering an educational itinerary on the career tracks and technologies of decommission and restoration. In the Aquitaine region, next to *the Megajoule* laser, "*Terre des Lasers*" offers a permanent onsite exhibition, a 200-seat auditorium and a practical work room to welcome high school and university students.

Laboratory visits, initiation to scientific approach

On top of those specific visit spaces, CEA scientists welcome high school and university students and teachers into their laboratories and experimental platforms. Despite the tightly constrained context due to the CEA specific activities, many visitors are greeted all year long or during particular 'open doors' days. In the last five years, CEA has implemented a largescale operation entitled "You are the scientist!" (*Scientifique, toi aussi!*), which reached out to roughly 1,500 high school students in only a day. This operation takes place simultaneously on ten CEA sites and at the National Center for Research in Human Genomics (*Centre National de Recherche en Génomique Humaine*, CNRGH), and allows high school students to obtain a concrete sense of research career development at the time when they have to choose a curriculum, before the *ParcoursSup* (former APB) deadline[115]. For students, this day is also an opportunity to meet various scientists, technicians, engineers, researchers, and visit various installations and research labs.

At an informal level, numerous scientists have already established collaborations with certain classes to present their research activities. Most CEA sites are now launching initiatives to foster those exchanges. For instance, the Cadarache site has implemented a long term tutorship with middle and high school pedagogical teams. The aim of this tutorship is not to replace teachers but to rely on them and to offer them an opportunity to build a project with scientists. The Cadarache CEA center has two participative science projects with local schools, which allow students, with their teacher's help, to have a first-person experience of research. The aim is not to "pour knowledge" on students but to build working hypotheses and methodologies, within an experimental framework around a particular problem. The first project, LUCIE, was about radioactivity surveillance in the environment: students have performed a measurement campaign in their own environment with a Geiger counter set at their disposal by CEA. Students fed those measures into a public and participatory database, SAFECAST. The second project, Solstice, was about global warming, which could have a significant impact in the Mediterranean area. In each project, CEA transfers knowledge and skills and gives access to all necessary instruments. Students work with their teacher on the implementation of the experimental method. They are then invited to visit CEA and present in English a poster summing up their scientific approach and results. This action is particularly original because it does not aim at a

[115] *ParcourSup* is an online enrollment platform, where high school students apply for university admission on specific programs. University access in France is non-selective and open to all high school graduates.

vertical dissemination of knowledge but at guiding students into building knowledge, understanding the scientific method, and sharing data with the scientific community.

All actions are led in agreement with the Ministry of National Education. At Cadarache, a convention between the rector of *Académie d'Aix-Marseille* and the director of the CEA center was signed in 2010 and renewed in 2015 for a span of 5 years. Our interlocutors have underlined the importance of such a convention to move forward confidently with teachers.

At the Saclay center, in the same spirit, the *Institut de Recherche sur les lois Fondamentales de l'Univers* (Research Institute on fundamental laws of the Universe, IRFU) participates in the organization of international master classes at CERN, which have gathered more than 10,000 high school students from 42 countries over more than 12 years. Mentored by researchers, high school students analyze the LHC (*Large Hadron Collider*) dataset. After each session, students hold a videoconference with CERN at Geneva to confront their results with those of other students.

Every CEA center and the central Communication Division have developed tight bonds, formalized or not, with the rectorates of their region. The partnerships developed by the Cadarache center with the *Académie d'Aix-Marseille*, Marcoule/Visiatome with the *Académie de Montpellier* and CESTA with the *Académie de Bordeaux* are particularly important.

The example of the Grenoble center is particularly interesting. Since 2009, the GIANT Program Coordination Department[116] collaborates with the local rectorate and develops methodologies to insert scientific contents into national education curricula. It implements a wide range of actions for middle school, high school and university students, and the general public. For middle school students, vocational orientation is still completely open, and the target of the actions is to create vocations by rendering science more accessible through the interventions of scientists in class. The program entitled *La Recherche fait École* ("Science Sets An Example"[117]), carried by 18 teachers and 15 CEA speakers, has been launched more than 20 years ago in 1996. Since its inception, it reached out to more than 12,000 students.

For students aged from 16 to 18, projects submitted to students and teachers have been carried over several months through the Giant@school initiative, which reaches out to more than 2200 students and 125 teachers a year. The basic principle is to create a back-and-forth exchange between the class and the lab through the implementation of an educational project centered on a scientific problem. Each project is led by a teacher and a project coordinator. With the help of a teacher who received a specific training on that problem, students work for 8 weeks in class before being immersed during an entire day in the campus Minatec[118] research infrastructure.

[116] https://www.minatec.org/fr/education/nanoschool/enseignants-et-lyceens/

[117] The name of the program is a hard-to-translate pun, since *faire école* ("making school") in French means "setting an example, setting a precedent".

[118] Innovation campus in micro and nanotechnologies in Grenoble: https://cime.grenoble-inp.fr

This initiative was agreed upon by the Ministry of National Education after a call for projects by the rectorate. Created in 2009, the Nano@school[119] initiative is the oldest and most emblematic among those Giant@school programs. It has reached to a considerable number of high school classes in the *académie* (25 in 2017-2018). It is coordinated and organized through a close partnership between GIANT, the rectorate of the *Académie de Grenoble*, local government *Conseil général de l'Isère,* and CIME Nanotech[120], a technological platform built on a partnership between *Université Grenoble Alpes* and the engineering school Grenoble INP, which is a member of the National Coordination for Training in Microelectronics and nanotechnologies (*Coordination Nationale de la Formation en Microélectronique et nanotechnologies*, CNFM). In 2013, the Innov@school program was launched to complete the Giant@school initiative. Conceived specifically for students in *Sciences et Techniques de l'Ingénieur* ("Sciences and Technologies for the Engineer", STI-2D) and *Sciences de l'Ingénieur* ("Sciences of the Engineer", S-SI), this program aims at a discovery of the career paths of innovation and technology transfer, and allows students to experiment the key steps of the innovation process. After a morning dedicated to the discovery of technologies created in the CEA labs, the afternoon is placed under the sign of creativity. This approach presents technologies from the standpoint of a social issue, such as supporting the visually impaired, increasing recycling rate for plastic waste, or transportation in 2050. Students are supported by innovation professionals who invite them to brainstorming and initiate them to design thinking.

Training for teachers

At the initiative of several researchers well-known for their talent as mediators, the CEA pedagogical action mission has put in place a three-day training session for high school science teachers. Inspired by British Science Learning Centres, this training session called *La Science en Marche* ("Science in Motion") offers teachers an immersion in the world of active research. Teachers have an opportunity to meet researchers, discuss ongoing research with them and watch demonstrations in laboratories. Building on the physics-chemistry programs in high school (general education), the correspondences established with the ongoing research programs in CEA labs have led to the elaboration of the session. The aim of this training session is to provide teachers with resources they can straightforwardly use in class and ready-to-use activities in physics and chemistry (scientific results, practical exercises, tricks, documents studies). Teachers gather six months later to provide feedback, in order to improve training over time.

Internship *Science pour tous*

After the success of the first two pilot experiments in March 2016 and January 2017, the Communication Department decided to renew this operation in 2018 in partnership with the

[119] http://www.nanoatschool.org/

[120] https://cime.grenoble-inp.fr/?q=en

collège Robert Desnos in Orly (*collège REP+*[121]). The internships for the last year of *collège*[122] *Science pour tous* ("Science for Everyone") are designed for students whose parents do not have the necessary network to open up professional opportunities beyond their immediate industrial and commercial environment. The development of critical thinking is also at the core of the project.

Publicizing the CEA educational offer

In 2013, the Communication Department set in motion a monthly newsletter *CEAScope, le rendez-vous de la culture scientifique du CEA* ("CEAScope, the meeting of scientific culture at CEA") with a readership of 9000, mostly teachers.

Main drivers:

1. The essential driver is passion and good will. A small group of researchers act as leaders with their high motivation (about 200 scientists for the actions of the Communication Department).
2. Educational actions have been made official by the General Division, which is essential to give them legitimacy.
3. Communication with National Education authorities help to build up trust with teachers.
4. Paradoxically, the downfall of the country in the PISA classification may also act as a driver, since it makes a strong political reaction mandatory.

Main barriers:

1. It is not easy to evaluate long-term efficiency of an educational action. After meetings with researchers and laboratory visits, the feedback is very positive but their impact is hard to measure in the long run.
2. Visits are many but security constraints remain important, especially after the 2015 terror attacks. Some spaces, which would be perfect for mediation, are hardly accessible. For instance, the EL3 nuclear reactor at Saclay is still in restricted area, while it could become a flagpole for CEA.
3. Researchers' worktime is becoming increasingly precious, especially because of the inflation of administrative tasks.
4. CEA is sometimes perceived with a certain distrust by actors from education and culture, who at first tend to be rather opposed to nuclear energy.

[121] Primary schools and *collèges* with a high proportion of socially disadvantaged students are classified in a REP (*Réseau d'Education Prioritaire,* "Priority Education Network"), and are given supplementary means to promote equal opportunity. REP+ means *Réseau d'Education Prioritaire Renforcée* ("Reinforced Priority Education Network"), and adds an extra layer of support measures for the most disadvantaged establishments.
[122] In the French school system, students finishing middle school (*collège*) have to make a short internship in a corporation or administration.

5. In the evaluation of researchers, time dedicated to science education is simply not taken into consideration.
6. CEA pedagogical mission does not have a specific program targeting science denial (climate change denial, etc.), however this problem clearly exists in the French society.

Points of improvement:

1. CEA needs to develop strategic thinking on its educational activities. A synthesis of all pedagogical resources developed in partnership with the *Académies* should be prepared.
2. There should be a national coordination between research institutions to update school programs, in coherence with the current high school reform for scientific disciplines, as exemplified by the Villani-Torossian mission on mathematics[123]. This coordination should be launched by the Ministry of National Education.
3. The time dedicated to science education should be valued in the researchers' evaluation. They are part of the mission of CEA as defined in the performance agreement and the CEA 2016 decree, which should be passed into the internal performance agreements.
4. There should be an annual report presenting in detail all relevant indicators for science education: numbers of involved students and teachers, number of created documents, participation of CEA staff (in person-months with annual evolution), integration in official curricula, financial resources and equipment, media impact study (number of articles, webpages and videos mentioning the actions), perception study within CEA staff.

[123] The current Ministry of National Education, Jean-Michel Blanquer, asked Fields Medal awardee Cédric Villani, and National Education general inspector Charles Torossian, to write down a report on mathematics education in the French primary and secondary system. It was officially presented to the Ministry on February 12th 2018: http://www.education.gouv.fr/cid126423/21-mesures-pour-l-enseignement-des-mathematiques.html

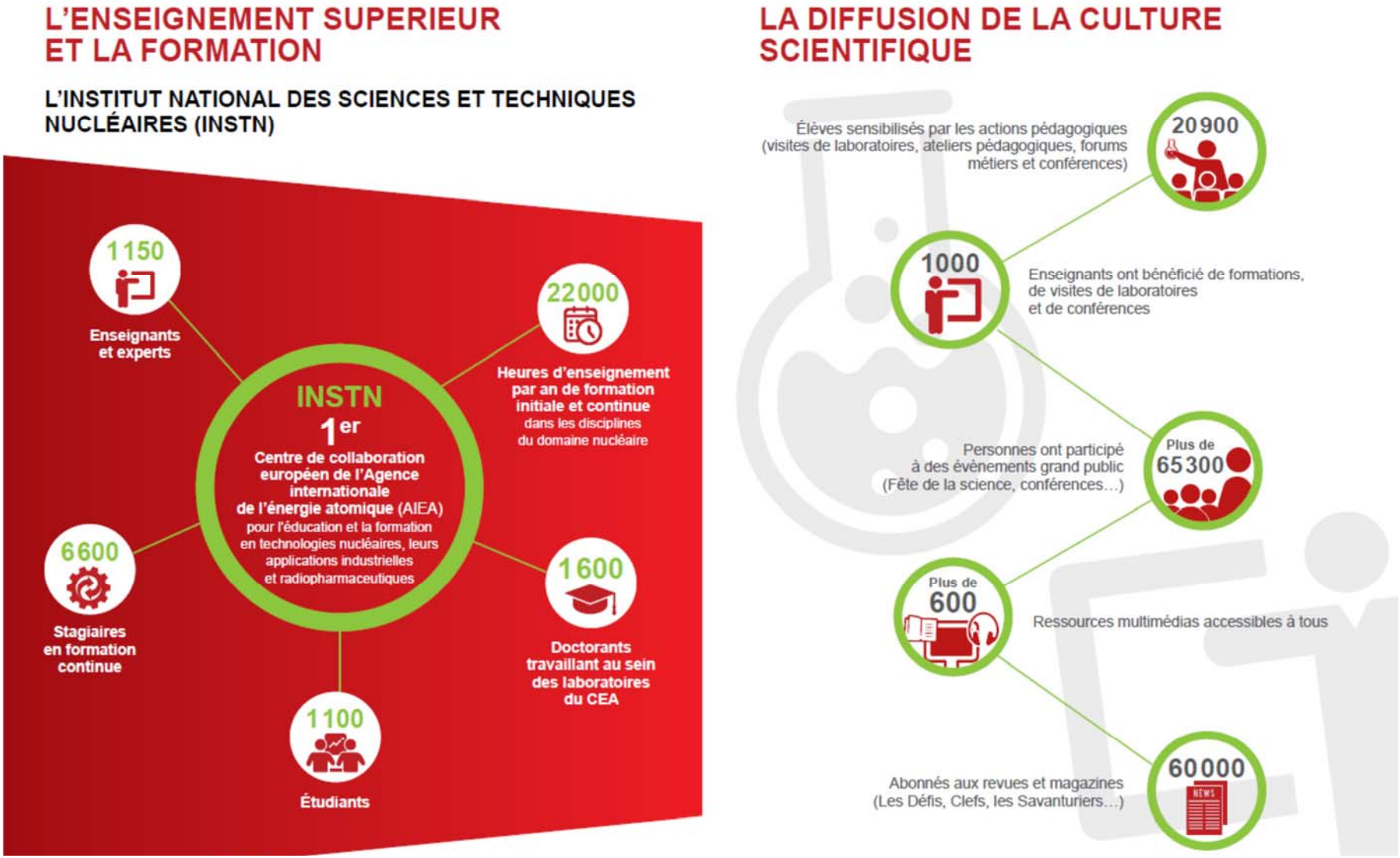


Figure 2. Dissemination of scientific knowledge at CEA (source: CEA Communication Department)

5.6 Research ethics and scientific integrity

In a March 2010 letter written to the Parliament by the Programs Unit of the General Division, the CEA position on research ethics, as well as a set of its actions on this topic in the 2000s, is summarized as follows:

> Beyond possible sanitary and environmental impact, the rising power of new technologies raises ethical issues, i.e. issues for which the existent norms (legal, moral,…) do not give simple and universal answers. This lack of preconceived answers necessitates reflections and researches from stakeholders. It has precisely been the CEA approach to nurture its scientific researches with reflections and studies on ethics. This reflection relies especially on the *Laboratoire de Recherche sur les sciences de la matière* (Research Laboratory on Matter Sciences, LARSIM).
>
> CEA did purposefully not create an internal ethics committee but decided to innovate by creating LARSIM in 2006. Under the leadership of physicist and philosopher Étienne Klein, this laboratory does not pursue research *in* physics but *on* matter and life sciences, in order to answer society's questions. Its objective is to reconnect the latest scientific trends (nanotechnologies, animal experimentation, for instance) with society, to help scientists explore the social impact of their work, and to explain to the general public issues at stake in scientific research. The dual role of LARSIM researchers, both physicists and philosophers, makes this lab particularly interesting.
>
> LARSIM adopted a research approach on science-society relations, the values of which underpin controversies on some technologies, such as nanotechnologies, or, from a fundamental perspective, issues connecting physicists and philosophers, such as the notion of time.
>
> In Grenoble, the Minatec Ideas Laboratory® gathers CEA experts, industrial actors and social scientists to imagine and conceive future products and services in micro- and nanotechnologies: this organization allows to take the public's opinion into account in the upstream phase of technology development.
>
> The Grenoble center also takes part to the "Umanlab", a social science research team created with the *Université Pierre Mendès-France*.
>
> In general, CEA also participates to the debate on nanosciences.

The creation of LARSIM is a unique experiment among French research institutions. It allowed CEA to develop its own expertise on social topics, especially on nanotechnologies, animal experimentation, synthetic biology, robotics and artificial intelligence. LARSIM reports and publications on those topics, inside and outside CEA, its activities, particularly in educational programs and media, have increased the visibility of the ethical reflection at CEA with a "diffuse ethics" model.

This position on ethics characterized CEA actions between 2006 and 2015. It had to evolve after the modification of the national legislative and regulative frameworks. In June 2016, a commission presided by Pierre Corvol stated in its report that "CEA does not have a dedicated body dealing with the integrity of scientific data, even if each operational division has set in motion a procedure for publication authorization in each of its units…"[124].

Since May 2016, CEA has launched an internal reflection in order to create an ethics committee. In February 2017, this reflection led to the publication of a Note by the High Commissioner, which opens on the following observation:

> With regard to existing structures in other public research institutions, CEA is facing a tacit or explicit demand (e.g. 2009 and 2014 AERES reports recommending the creation of an internal body dedicated to ethics and deontology within CEA) to set in motion an ethical and deontological reflection. From a more general perspective, this reflection is necessary because CEA research fields raise de facto ethical issues (matter and life sciences, especially genomics, animal experimentation, high speed numerical computation, Big Data, etc.)

CEA needs in terms of ethics and deontology can be analyzed into three distinct modalities:

> A body dedicated to deontology to treat on a case-by-case basis the possible breaches to the principles applied at CEA and in the scientific community.
>
> An answer to ancillary needs to fill in "Ethics" items, which are more and more frequent in national and international calls for projects and contracts.
>
> In-depth thinking on ethical issues related to science and technology evolution, as well as scientific practices and technologies related to the evolution of ethical positions.

The first two modalities are under the responsibility of the CEA Administrator General. In February 1st 2017, he signed a national deontology chart for research jobs and named in the spring of 2017 a *Directeur de la conformité et du contrôle interne* ("Compliance and Internal Control Director"), who is, among other duties, in charge of implementing measures provided by the December 9th 2016 Sapin II law related to the fight again corruption (code of conduct and complaint management mechanisms). In January 2018, the Administrator General named a scientific integrity officer in application of March 15th 2017 Ministry of Higher Education and Research circular letter. This officer is in charge of building a structure allowing to implement the scientific integrity targets defined by the Ministry.

The third modality in the aforementioned Note is entrusted to an ethics committee (*Collège d'éthique*). As an independent body, this CEA ethics committee is placed under the authority

[124] *Bilan et propositions de mise en œuvre de la charte nationale d'intégrité scientifique,* ("Overview and recommendations on the national scientific integrity chart"), report submitted to Thierry Mandon, state secretary for Higher Education and Research, by Pr. Pierre Corvol, Honorary Professor at the Collège de France, Honorary Administrator of *Collège de France*, June 29th 2016, page 17. Available at https://cache.media.enseignementsup-recherche.gouv.fr/file/Actus/84/2/Rapport_Corvol_29-06-2016_601842.pdf

of the High Commissioner for atomic energy, an independent personality in charge of presiding over the committee. This *Collège* consists of members of the Committee of the Wise and CEA researchers interested by a given topic of reflection.

The Committee of the Wise includes top-level scientific personalities associated with technical and scientific experts selected for a specific topic. This committee is in charge of writing reports that can rely on previous work by various experts, interviews and internal exchanges with all CEA researchers concerned by the topic in question.

On a given subject, the committee has twelve months to conduct its work and submit a report with recommendations to the Administrator General and the CEA Scientific Council. This report should be agreed upon by the committee in a plenary session. After receiving advice from the Scientific Council, the CEA Executive Board is in charge of deciding on the further course of action, in particular on partial or complete publication of the report.

For 2018, the topic of the ethics committee work is "artificial intelligence related to CEA research".

Indicators and integrity: a discussion

In order to implement relevant indicators for research ethics, the activity of scientific integrity referents and ethics operational committees should be analyzed at the national level. A fine-grained categorization of actual complaints, allowing to understand their type and severity, would also be desirable.

The interpretation of those data would raise the following essential issue. A low breach rate in an institution or country can be a sign of ethical good health, but it can also be a sign of a culture of silence and fear of scandal, preventing the reporting of ethical breaches, or creating a complaint management behind closed doors. That is why it would be preferable to talk about "reporting rate" rather than "breach rate".

As a consequence, taking the reporting rate as an indicator could have undesirable adverse effects, giving the institutions an incentive to repress reports rather than go public. On the other hand, institutional progress in ethical bodies could provoke a temporary rise in reporting rate, thanks to whistleblowers, and a higher proportion of cases made public.

Quantitative indicators cannot do justice to the depth of necessary transformations. In order to promote ethical behavior, a major turnaround in institutional culture is in order: the reputation of an institution should not be attached to the existence of a breach of ethics but to its treatment. If publicity made to a given breach is systematically used against the institution where it happened, this institution faces a terrible dilemma, having to choose between the sacrifice of its reputation in the name of ethics or protecting the culprits and repressing whistleblowers to preserve its public image. Centering the evaluation of institutions on the treatment of breaches, and not on their existence, would greatly encourage the promotion of ethical behavior within institutional culture.

Animal experimentation ethics at CEA

The Bureau for Biomedical Studies (*Bureau des Etudes Biomédicales*, BEBA) at CEA registers all authorization requests for projects using animals, monitors them on behalf of CEA institutes and centers, and assumes the function of delegate of center directors with the Ministry, which consists in reviewing and submitting project authorization requests in compliance with regulatory demands.

The Ethics Committee for Animal Experimentation at CEA (*Comité d'Éthique en Expérimentation Animale du CEA*, CEtEA) has 19 current members, who are nominated for a renewable 3 years mandate, in order to provide multi-disciplinary competences as demanded by regulation: (i) veterinarians; (ii) technical staff representatives, who are competent for the implementation of experimental procedures on animals; (iii) zootechnicians' representatives, who are competent for medical care and euthanasia on animals; (iii) personalities chosen outside the establishment conducting the experiment, or Users' Establishment (*Établissements Utilisateurs*, EU), who are competent in social sciences, show interest for animal protection or are competent in laboratory animal sciences and technologies; (v) research engineers, who are competent for the conception of projects and experimental procedures.

In compliance with current regulations, the recommendations of the National Committee for Ethical Reflection on Animal Experimentation (*Comité national de réflexion éthique en expérimentation animale*, CNREEA) and the principles of the National Chart on ethics for animal experimentation, CEtEA proceeds to the systematic ethical evaluation of authorization requests for all regulatory or scientific projects using animals, which can be submitted by eight Users' Establishments in its perimeter. CEtEA issues an opinion and, if need be, recommendations to be implemented before the experiment, and provides follow-up for projects. A favorable ethics opinion is required before the start of an experiment.

In 2017, 92 new or existing requests have been analyzed by CEtEA, which shows a relatively constant work rate compared to preceding years.

There exists a network of 35 ethics committees in Ile-de-France (Comet IdF), which was founded in 2011 at the initiative of the ethics committees for animal experimentation at INRA Jouy-en-Josas-AgroParisTech (COMETHEA) and CEA (CEtEA) with the support of the National Veterinarian School at Maison Alfort (ENVA). Its aim was to harmonize ethical evaluation and consolidate scientific watch and ethical competences. The network has a bureau, which meets on a monthly basis and receives advice from BEBA.

For several years, CEtEA has been redacting, with the support of BEBA, technical reference guides to help project designers and help harmonizing methods and criteria for ethical evaluation.

The annual workshop "Ethics and Animal Experimentation" is organized jointly by CEtEA, BEBA, the Structure for Animal Well-Being (*Structure chargée du bien-être des animaux,* SBEA) and the Communication Unit (UCRP) of the CEA center at Fontenay-aux-Roses. The November 14th, 2017, session focused on animal models. This workshop, which counts as a training session, is intended for all personnel (researchers, equipment managers,

zootechnicians, safety engineers, students, external collaborators) as well as guests from other external ethics committees. The strong turnout (172 participants) shows the success of the operation.

Main drivers:

1. The evolution of national regulatory frameworks for ethics and scientific integrity spurs action in CEA.
2. The need to train doctoral students on scientific integrity encourages reflection within CEA.
3. The demands in ethical analysis and review in the projects funded by the European Commission (H2020 programs, ERC) give CEA an incentive to think about the implementation of adequate committees and structures.
4. The existence of LARSIM, a laboratory dedicated to philosophy of science and science-society relations study.

Main barriers:

1. There are difficulties in establishing the authority of an ethics committee within a management structure geared towards particular tasks of the performance agreement.
2. There is a perceived incompatibility, inside and outside CEA, between ethics and certain CEA research fields, such as nuclear energy and national defense.
3. Lack of training and experience among CEA researchers on the formalized treatment of ethical issues.
4. Existence of a culture attaching the reputation of an institution to the existence of breaches to ethics, rather than the treatment of those breaches.

Points of improvement:

1. Developing research on ethics at LARSIM.
2. Strengthening training for doctoral students and CEA permanent staff.
3. Choosing several “ethics and integrity” indicators adapted to the situation of CEA.
4. Answering the demands of the European Commission on ethics analysis and review for projects funded by ERC and H2020 programs by creating an ethics operational committee within CEA, with a networks of correspondents in the centers and operational divisions.
5. Implementing a structure allowing the scientific integrity officer to carry out his mission.
6. Promoting scientific and ethics training for researchers at a national level, especially in engineering schools.
7. Creating an anonymous or protected procedure to report breaches of scientific integrity and a transparent repository of conflicts of interest declarations.
8. Implementing a database of indicators for ethical issues: absolute numbers and percentages of cases and reported breaches, percentage of external members in ethics committees, results of perception studies of ethics action in CEA staff (perception of encouragement to ethical behavior in the institution, awareness of existing institutions and procedures).

A general indicator of success: the analysis and review procedures should answer to the criteria of a national and international audit of the highest level.

5.7 Public engagement

Relations with CLI

Local Information Commissions (*Commissions locales d'information*, CLI) associated to geographical sites holding large energy equipment were initially created by a December 15th, 1985, circular letter signed by the then Prime Minister Pierre Mauroy. At the time they were facultative, depending on the initiative of the president of the local *Conseil départemental*[125]. They only became mandatory at each *Installation Nucléaire de Base* ("basic nuclear equipment", INB) or sites containing several INBs after the June 13th 2006 law on transparency and safety in nuclear energy, now codified in the code for the environment[126]. The first CLI associated to a CEA center was created in 1993.

CLIs are in charge of a general mission of review, information and concertation on nuclear safety, radioprotection and impact of nuclear activities on the public and the environment for the relevant INBs. They organize a public meeting at least once a year, and can take up any topic in their field of competence. Each CLI contains four different colleges: local representatives, union representatives, NGOs, and qualified professionals. They make sure that the result of their work is largely disseminated to the general public in an easily accessible form.

In various regions where CEA is located, CLIs have varying rates of activity, frequency of meetings, or allocated resources. The most active CLI is attached to the Cadarache center. Its staffs counts up to 44 members and its annual budget is 260,000 euros, with contributions from the *Conseil départemental des Bouches du Rhône* (55%), the *Agence de Sûreté Nucléaire* (ASN, Nuclear Safety Agency) (25%) and other levels of local government (20%) (*Région PACA, conseils départementaux du Vaucluse, des Alpes de Haute-Provence et du Var, Métropole Aix Marseille*, and 16 municipalities within a 5km radius). Between 2 to 3 persons are permanent staffers of the Cadarache CLI, in charge of writing and publishing a magazine, organizing studies within the local population and performing measurements in the environment. This CLI has close to 30 annual meetings; by comparison, some other CLIs have only one annual meeting. The Cadarache CLI is very active on all issues, featuring a critical, sometimes even a contradictory position on the Cadarache activities; this sometimes spurs a vehement argument at public meetings. Nevertheless the CEA Cadarache representatives, including its director, regular take part in CLI public meetings and other public events, e.g. those organized by the *Collectif anti-nucléaire Sud-Est* ("Southeastern Anti-Nuclear Collective").

This example from the Sud-PACA region reveals that the method of public engagement through public meetings has shown its limits. Such meetings attract a very small audience with a majority of anti-nuclear activists. Because of this weakness in sheer number and in

[125] The *Conseil départemental* is a council ruling over the *département,* a local government district somewhat similar in size to British counties.
[126] Articles L. 125-17 à L. 125-33.

representativity, it is safe to say that these meetings do not significantly contribute to the dialogue between science and society. Articles in local newspapers attract more attention and a larger readership, even if such publications require a considerable financial investment from the Cadarache center, via partnership with local media. Currently CEA Cadarache publishes a monthly page dedicated to the activities of the center.

Positive public engagement is also attested at events such as the national science festival (*Fête de la Science*) in the neighboring towns and bigger cities. Together with these events, various conferences, forums, workshops in schools, visits of the Cadarache center have allowed to reach out to approximately 25,000 people in 2017.

Participation to studies and public debates

In compliance with international conventions signed by France and with European directives, the principles of: a) information of the public; b) participation in public decisions that have an impact on the environment are enshrined in law[127]. The law creates an obligation of particular engagement measures, i.e. public studies on the implementation of projects with high environmental risk, prior to the elaboration of equipment or infrastructure projects with high environmental impact, and on land use.

CEA organizes public studies during creation or modification of certain high-risk installations and participates in public debates organized by the *Commission Nationale du Débat Public* ("National Commission of Public Debate", CNDP) or by specific commissions for public debate. For instance, a debate was recommended to CEA for its radioactive waste processing and storage project at Cadarache (CEDRA, 2001) and organized by CEA in 13 municipalities around the Cadarache center.

In 2009-2010, CEA also participated in the CNDP-run national debate on nanotechnologies, publishing a report on its activities and organizing a meeting in every CEA center. CEA researchers took part in public meetings during that debate.

CEA in the *Diagonale Paris-Saclay*

CEA is a member of the *La Diagonale Paris-Saclay* select steering committee. This initiative aims at fostering science-society dialogue inside the *Univeristé Paris-Saclay*, which gathers some of the largest education and research institutions in the country. This outward-looking structure tries to create bridges between scientists and stakeholders from society. Its mission is to support the creation and dissemination of projects and to organize activities in science

[127] Article L. 110-1 from the *Code de l'environnement.* Available at http://codes.droit.org/CodV3/environnement.pdf

mediation, cultural heritage, and art-science interaction. It takes part in the University Paris-Saclay mission of scientific and technical culture dissemination.

The *Diagonale* translates an ambition for a direct interaction between scientists and society: local population, students, artists, industrial, societal and political stakeholders. Researchers or university professors are involved in each of its actions. The *Diagonale* works in close collaboration with scientific culture associations, local government and corporations. Those entities are represented in the governing board.

As a member of the steering committee and the stakeholders' assembly (*collège d'acteurs*) of the *Diagonale*, CEA takes part in the definition of its strategy and actions. Its researchers are involved in numerous projects carried out by the *Diagonale*.

Open Labs at CEA Grenoble

Founded in 2011, Ideas Laboratory[128] is a unique Open Lab in France. Housed at the Grenoble CEA center, it is a multi-partner innovation platform gathering CEA-Teach, France Telecom, ST Microelectronics and Hewlett Packard. Its mission is to conduct collaborative innovation projects whose aims are defined by participants and whose financial and human means are mutualized. Its approach is built around "the meaning for humanity". Ideas Lab works with large industrial groups, small businesses, research centers, local government, schools, universities and NGOs. Thanks to the CEA experts and technological research labs, Ideas Lab has the ability to monitor technological developments and carry out technological projects. Various disciplines come into play: design, social sciences, applied sciences, literary and cultural studies, engineering, marketing, etc. Strengthened by all those resources and by shared expertise, Ideas Lab fosters disruptive innovation. The objective is to anticipate future social issues and to achieve innovative and meaningful projects.

Arts and science initiatives at CEA

Physics is a regular source of inspiration for artists, and this influence is a two-way street. Mutual echoes create a fruitful tension between these two polarities of the human mind. Some believe that science and art are two fundamentally different things: they imagine that they do science a favor if they suppress imagination or help art to make progress if they steer intelligence away from it. However, both science and art remain an essential part of the human condition. A dialogue between them is therefore essential, and a conversation between science and society cannot but have an artistic dimension.

[128] https://www.ideas-laboratory.com

Through several actions at Saclay (artist residencies, exhibitions[129], co-conception of art work), the Arts and Sciences mission attracts citizens who are either afraid of science or do not feel involved or able to interact with it. Art is thus the first tool of dialogue that allows one to move beyond fear and prejudice.

CEA Grenoble[130] Arts Sciences Workshop (*Atelier Arts Sciences*) is a research, creativity and innovation platform bringing together artists, scientists, local government, and corporations. Founded in 2007, it is the only platform of this type in France. Established by CEA, *Hexagone Scène Nationale Arts Sciences-Meylan*[131] and the *département de l'Isère,* it proposes common research projects to artists, scientists and industrial actors, in order to enrich artistic creation through new technologies and innovate via an artistic, free, out-of-mainstream approach. The Arts Science Workshop welcomes corporations willing to address innovation differently and to work in unusual ways.

The Workshop has the following missions:

- Innovate and create at the crossroad of art and science;
- Provide the conditions for fruitful meetings between artists and scientists;
- Explore new perspectives for art, technology and industry;
- Foster questioning and imagination;
- Confront experiences and viewpoints to enrich work methods of all participants;
- Allow each participant to build her own worldview consistent with changes induced by scientific progress and new technologies;
- Transfer the results of residences into industrial innovation.

The workshop organizes research residencies, the *Biennale Arts-Science* EXPERIMENTA fair at Minatec-Grenoble[132], with the support of local government (*département, métropole, région*) and corporations (Vicat, Renault, Orange, La Cool-Co, Chenel, Mind…)

Residencies are dedicated to research work common to artists and CEA researchers (Grenoble, Saclay) on subjects proposed by artists, scientists or corporations. They can last from 3 months to 3 years. They culminate in performances, shows, objects, art installations, prototypes or ideas. They are presented for the first time at the EXPERIMENTA biennale, on stage (*Hexagone Scène Nationale Arts Sciences* at Meylan and tours in France and abroad) or in showrooms (MAIF Social Club Paris, world's fair, *Palais de la découverte*[133], etc.).

[129] http://www.cea.fr/presse/pages/actualites-communiques/institutionnel/e-mc215-dialogues-entre-sciences-et-art.aspx
[130] http://www.atelier-arts-sciences.eu
[131] The *Hexagone Scène Nationale Arts Sciences* is an association dedicated to arts and sciences initiatives, bringing together science education and performing arts. It is located at Meylan in the Grenoble suburban area. Website: https://www.scenes-nationales.fr/scene_nationale/hexagone-scene-nationale-arts-sciences-meylan/
[132] https://www.experimenta.fr/
[133] The *Palais de la découverte* is a large science museum located in Paris: http://www.palais-decouverte.fr/fr/accueil/

Corporations are increasingly interested by the workshop, for it brings disruptive innovation and out-of-mainstream approach. They particularly like short workshops (3 to 10 days) involving artists, scientists, designers and students.

Since its creation, 43 projects have been carried out by the team with the involvement of 150 CEA scientists.

Through the public relation team of *Hexagone Scène Nationale Arts Sciences,* the workshop leads an important work of information and training towards the young public. 600 students per year, from middle school to university, receive classroom visits by scientists and artists. There is also art&science training for teachers, organized jointly with the rectorate.

EXPERIMENTA is both a biennale and an Arts-Science-Technology fair, presenting projects carried by an artist-scientist duo. These are the products of *Atelier Arts Sciences* residencies but also other European (Latvia, Germany) and even extra-European collaborations (Japan). Numerous French projects are also exhibited. EXPERIMENTA welcomes between 5,000 and 6,000 students with organized tours, and allows the public to test the art installations and discover numerous performances (2,940 participants for performances only).

Main drivers:

1. In many cases, public authorities require a public debate on technological development, especially for large scale infrastructures located in a specific territory. As a consequence, local government (*Grenoble Alpes Métropole, Département de l'Isère*) supports the *Atelier Arts Sciences* in order to integrate the entire population in the most inclusive process possible.
2. In contrast with the polarized atmosphere of public debates, *Atelier Arts Sciences* proposes a different method for public engagement through the creation of a sensorial and emotional space open to all audiences and citizens. This avoids reducing the science society interaction to its epistemic dimension.

Main barriers:

1. Public debates on scientific and technological projects are often usurped by small groups of vocal opponents and do not provide an opportunity to express the entire spectrum of opinion. A binary debate, where the choice is seen as dichotomic, even sometimes as a choice between absolute good and absolute evil, does not enlighten thinking and polarizes public opinion ever more than before.
2. It becomes increasingly difficult to mobilize scientists willing to get involved in mediation action in schools. This isn't due to a lack of interest but to a rigorous imposition of tasks and work hours by superiors.
3. In order to reach international standards, it is absolutely necessary to at least quadruple the activity of *Atelier Arts Sciences* and of EXPERIMENTA. This would need a lot more human and financial resources, which are hard to find a strained economical context for an activity that is not directly profitable.

4. In the *Art Sciences* initiatives, disseminating scientific knowledge is not necessarily the primary objective, or even not an objective at all. Some scientists perceive this as an obstacle.

Points of improvement:

1. In the framework of the *Transversale des Réseaux Arts Sciences*[134], it has been proposed to enlarge the perimeter of arts and science programs to every CEA center and division. To this aim, a dialogue with theaters located in towns neighbouring CEA centers has been considered.
2. Organize media training sessions for researchers in order to train them to the techniques of contradictory debate.
3. Following the lead of *Atelier Art et Sciences*, reflect on the interest for CEA to develop public engagement tools beyond the usual methods, whose limited efficiency has been demonstrated.

5.8 Gender equality strategies

Women represent 32.9% of all CEA employees. This rate decreases to 26.6% among engineers and managers, corresponding approximately to the proportion of female students at French preparatory classes[135] and engineering schools.

The situation is progressively improving: the rate of female researchers recruited in 2016 (32.8 %) is significantly higher than the rate of female students currently enrolled in engineering curricula (28.1 % at the start of the 2015-2016 academic year).

For about thirty years, quantified assessments of gender equality have been produced and published in "comparative situation reports" (*rapports de situation comparée*) available internally to all CEA employees. They do not show evidence of massive discrimination but a slight misbalance in certain situations, e.g. a weak proportion of part-time female employees in upper echelons and weaker career development for female employees having taken an unpaid leave.

In order to promote a proactive policy on gender, CEA signed on September 14th, 2011, and then renewed on October 10th, 2017, agreements relative to the "promotion of professional equality between women and men" and the "necessary articulation between professional life and personal life". These agreements contain a 3-year plan focused on 3 axes: fostering diversity, applying the principle of equal pay and equal professional evolution, and conciliating private and professional life. This plan was the topic of a dedicated "zoom" in the internal

[134] La *Transversale des Réseaux Arts Sciences* is a network of arts and sciences stakeholders: https://www.theatre-hexagone.eu/tras/la-transversale-des-reseaux/

[135] In France, many of the best high school students do not attend university in their first years of higher education, but go instead to "preparatory classes" (*classes préparatoires*) where they prepare for the competitive admission exams of prestigious schools, such as many of the most renowned engineering schools.

magazine *Talents* n°166 (January-February 2018) and is also available on the web[136]. It states, in particular, that:

- The proportion of female employees among permanent staff will increase through maintaining an annual recruitment feminization rate 5 points above the existing rate among CEA personnel;
- The proportion of recruitment of non-scientific employees in the administrative sector (female majority) and technical sector (male majority) should be balanced;
- Maternity, paternity and adoption leaves should have no incidence on career development.

The Human Resources Division has created a statistic reference point to compare the current situation to the agreement targets. It has also named a *Référente égalité professionnelle* ("professional equality officer"). There is no "women's network" at CEA but the institution has a partnership with the *Inter'elles* circle, which promotes professional diversity and equality in scientific and technological sectors.

The performance agreement between CEA and the French State for 2016-2020 defines an indicator for the feminization rate of decision-making positions, in management as well as in scientific expertise. No target has been set but an increase from the 2015 reference point (20.5%) is both mandatory and expected.

In June 2013, a large online study was conducted on the "perception of women/men equality at CEA", consisting of 80 questions on self-perception in the professional setting, perception of balance between private and professional life, diversity policy, and the place of stereotypes in the institution. All CEA employees independently of status or age (around 19, 000 agents) could answer this study. 3389 answers were registered and analyzed, half coming from women. They show a significant difference in perception between men and women:

— 72% of men and only 44% of women think that men and women are treated equally by their superiors;
— 37% of men consider that women and men careers at CEA are equivalent, only 8% of women share this opinion;
— 71% of men think that men and women have the same opportunities for reaching high-level positions, while only 31% of women are of the same opinion.

In June 2018, the Administrator General decided that this study will be renewed regularly and serve as a reference point for the gender equality policies at CEA.

Main drivers:

1. Studies show that younger individuals, both men and women, are more likely to believe that professional equality exists and should exist, raising hopes that the new generation will be more demanding on this issue.
2. Proactive policies with numeric targets should make an impact in the medium term.

[136] http://www-drhrs.cea.fr (see *Dialogue social/Accords au CEA*)

Main barriers:

1. From an historical point of view, CEA was founded at a time when there had been few women among researchers, especially in physics. Thus CEA was historically impacted more than other institutions by cultural effects that take time to disappear.

Points of improvement:

1. Indicators show that CEA is in relatively good position in comparison with other French research institutions; however, the perception within CEA staff is different. The perception of CEA agents should be taken into account through perception indicators, and measures should be taken to make them move in the right direction.
2. The question of women/men parity in CEA executive instances, especially the Scientific Council, should be raised.
3. Strong symbolic measures should be proposed, e.g. nominating women for positions of strong operational responsibility.
4. A sensitivity training on gender equality should be included in the training of CEA managers and executives.

5.9 Open access and open science strategies

The development of open access to scientific publications at CEA is centered on one major action: its participation to HAL (see section 2.6). Since 2014, CEA has a dedicated portal HAL-CEA, which is automatically integrated in the HAL national portal. In application of the *Note d'Instruction Générale* 660 ("General Instruction Note) of November 21st, 2014, HAL-CEA is the CEA institutional archive.

CEA does not have a policy at the institutional level with regard to green/gold open access to scientific articles. For instance, CEA articles developed in H2020-funded projects are exclusively in open access, since this is required by the European Commission since Spring 2017. However, other publications remain often behind the paywall, chiefly due to lack of dedicated funding for the rather expensive open access format. Global rate of open publications at CEA progresses very slowly. The NIG 660 demands the deposit of published papers in HAL-CEA open archive but there is no incentive for this measure and no deposit indicator.

As a matter of fact, even though the budgets allocated to subscriptions, especially paper subscriptions, have been decreasing for many years, CEA is still subscribing to numerous journals, mostly in electronic form. The advent of open access puts financial management of scientific publishing in a precarious situation. During a transition phase between the old practice of paid access and the new situation, characterized by the generalization of open access, CEA has to contribute both to subscriptions and to golden open access.

With regard to this problem, CEA situation is not different from that of most research institutions in France and in Europe. The dual financial constraint creates an excessive and unsustainable budgetary pressure, pushing CEA and other institutions to accelerate the transition towards generalized open access and the end of the subscription system.

A CEA roadmap towards Open Access and Open Data is currently under construction by the IST (*Information Scientifique et Technique,* "Technological and Scientific Information") steering committee. Its aim is to give CEA a chart on Open Access and to implement actions and tools to help departments and researchers to join into this transition towards Open Science.

Main drivers:

1. Obligation to publish in open access is imposed by some research funding agencies.
2. Better visibility for publications compared to an economic model of scientific publishing where subscription prices became so prohibitive that many labs would not subscribe even to the journals necessary for their research.

Main barriers:

1. Absence of an obligation for all CEA researchers to systematically deposit their publications on HAL.
2. Absence of monitoring of open access publications in the researcher's annual evaluation.
3. Restrictive nature of some studies under industrial secrecy or national defense, which precludes them from publication.

Points of improvement:

1. Introduce "Deposit in HAL/publication in open access" indicators for the researchers' evaluation inside operational divisions.
2. Include the "open access" topic in the ethics and scientific integrity training sessions, to give a clear overview of the legal framework and objectives of open access.
3. Actively participate in the current national initiative on open access.

5.10 Incorporation of RRI dimensions into policies

RRI education

There is no overall training branded as "RRI" but some aspects of RRI training are covered by the training provided on keys, e.g. ethics (pp.53-54) and science education (p. 41).

Responsiveness and adaptation, Openness and transparency

See "Ethics" and "Gender" keys for treatment of those dimensions.

Anticipation and reflexivity

Description of current practice and its dynamics: review of its operation

Anticipation exercises are led by several CEA units. Anticipation is treated there in all its dimensions, scientific and technological, economic and societal. The *Direction des Analyses*

stratégiques ("Strategic Analysis Unit", DAS) coordinates and carries the strategic analyses necessary for the elaboration, the implementation and the evolution of institutional strategies. It carries cross-sectional analyses on key topics, e.g. on the evolution of energy systems or on the digital transition.

Within the *Direction Financière et des Programmes* ("Programmes and Financial Unit", DFP), the *Direction déléguée aux Programmes* ("Programmes Unit", DPg) is in charge of annual and pluriannual programming at CEA in coherence with strategic orientations. DPg also coordinates, via a dedicated budget, four cross-sectional competence programs and exploratory programs, especially on computer simulation or materials and processes.

The High Commissioner acts as a technical and scientific advisor to the Administrator General. In this function, he leads a cross-sectional scientific reflection with chief scientists representing 26 disciplines.

Inside the *Direction de la Recherche Technologique* ("Technological Research Division", DRT), the *Service Marketing Stratégique* ("Strategic Marketing Service") carries technical and economic studies of the CEA technological offer in comparison with industrial demand and competing offers. Moreover, the Open Labs (Idealab[137], Alps Design Lab[138], *Atelier Arts Sciences*) and Factory Lab[139] create an open, innovative environment gathering technology users and providers: small, middle-sized and large corporations, start-up companies and research labs. CEA encourages the creation of start-ups from its technologies and support the competiveness of corporations through performance and product differentiation, and technology transfer originating from its labs.

Strategic partnerships with certain large corporations allows to steer CEA strategy towards the future needs of final users. Those structuring partnerships are led by the Strategic Analysis Unit.

Finally, among CEA operational divisions, the Scientific Divisions are in charge of coordinating scientific partnerships through a mobilization of research directors and experts.

Main barriers (structural, cultural or related to interchange dynamics)

The task of anticipation may be complicated by the compartmentalization of activities by theme. This may provoke lack of multidisciplinary approaches in research as well as in industrial development.

A tension may also be found between "techno-push" model, where innovation stems from technological evolutions, and "market-pull" model, which starts from market needs and adapts technological development accordingly. Frequent interaction between the Technological

[137] Idealab is a technology incubator: https://www.idealab.com/
[138] Alps Design Lab is a design school supported by CEA, located at Grenoble: http://www.alpsdesignlab.fr/
[139] Factory Lab is a platform supporting technological projects, founded by corporations and public research institutions, including CEA: https://factorylab.fr/

Research Division and industrial actors, who come to CEA looking for expertise in responding to market needs, forces an evolution towards a model dominated by the market pull approach.

Main drivers (structural, cultural, or related to interchange dynamics)

1. The economical imperative of innovation contributes to anticipation through the focus on novel use with its different aspects (technology transfer, start-up creation…). In particular, the digitalization of the economy fosters the emergence of new trends, which modify the economic and technological landscape. They cannot be anticipated by a simple extrapolation of existing uses.
2. A prospective approach: CEA takes part in the elaboration of national roadmaps, anticipation scenarios, expertise reports to enlighten public policies. Examples include the role of CEA in the hydrogen national roadmap and technological and energetic scenarios at ANCRE[140].

Best practices

Founded in 1993, the *Service Marketing stratégique,* formerly *Bureau d'Études Marketing* (BEM), includes thirty engineers specialized in market innovation and economic prospective. They aim at "studying markets that don't exist" (as the marketologist Paul Miller said), carrying more than 50 studies a year: competition analysis, offer structuration, benchmark, potential application analysis for a given technology.

For example, in order to study the opportunity of developing a new technological path, BEM creates a map of R&D efforts in the relevant field, with a zoom on the CEA approach. This state-of-the-art study allows one to conduct a systematic comparison with competing technological paths by assessing the level of maturity, foreseeable performances in the next 10 years, or likely challenges and barriers. This is then used to make a strategic diagnosis through SWOT (Strengths, Weaknesses, Opportunities, Threats). The existence of BEM is a unique case among French public research organizations.

Current indicators

There are a posteriori indicators of anticipation studies carried out at CEA. Beyond qualitative analysis (feedback from partners, efficiency of internal work…), it is also possible to review indicators on CEA key partnerships (duration, size, efficiency…) or job creation.

[140] ANCRE is a national alliance of researchers and actors of the energy sector, working to promote research on energy and the conception of energy public policies: https://www.allianceenergie.fr/

5.11 Other concepts used by CEA to characterize responsibility: Sustainable Development

Description of Sustainable Development: review of its current functioning

In line with its research missions on carbon-free energies, CEA has been involved for a long time in a sustainable development approach, which was formalized in 2006. In 2016, following the Paris climate agreement, the Administrator General took a commitment within the national effort against global warming, through a sustainable development approach adopted by all CEA centers. CEA contributes to the development of the French energy mix and the UN Sustainable Development Goals (SDG), in response to the demands of the French government.

In November 2016, CEA signed a sustainable development chart for public institutions and companies. The signatories commit to initiate (or to carry on) a social responsibility approach within their institutional strategic plan, their operational practices and their relations both with partners and other actors of their territory. This was the first action of the *Directrice du développement durable* ("Sustainable Development Executive Officer") following her nomination.

Sustainable development (SD) is somewhat different from corporate social responsibility (CSR) and RRI. At the Rio de Janeiro Earth Summit in 1992 SD was officially defined as consisting of three pillars: an economically efficient, socially fair and environmentally sustainable development. This implies that SD includes topics under the Gender and Diversity RRI key, e.g. recruitment and career development of female employees or persons with disabilities. CSR captures a contribution of corporations to those SD issues and, for CEA, to the goals of the national SD strategy.

At the time of this report, the Sustainable Development Executive Officer proposed a series of priority topics: energy production and consumption, sustainable mobility and dialogue with stakeholders. These could fruitfully joined with the CEA strategic tasks.

A strategic SD plan is approved by the CEA Executive Committee, updated every three years and translated into an action plan. The Sustainable Development Executive Officer relies on a network of SD correspondents and environment task officers, which is very active at CEA centers, as well as on functional divisions (*Direction de la communication, Direction de la sécurité et de la sûreté nucléaire, Direction des achats et des partenariats stratégiques, Direction des ressources humaines et des relations sociales, Direction juridique et du contentieux*). This approach will also be illustrated by an internal sustainable development chart which is currently being drafted.

Main barriers:

1. Low dissemination of concepts such as "corporate social responsibility" and "sustainable development" at CEA.
2. Very weak coordination between different CEA centers with regard to sustainable development.

3. Absence of dedicated means (only one Executive Officer, half-time).

Main drivers:

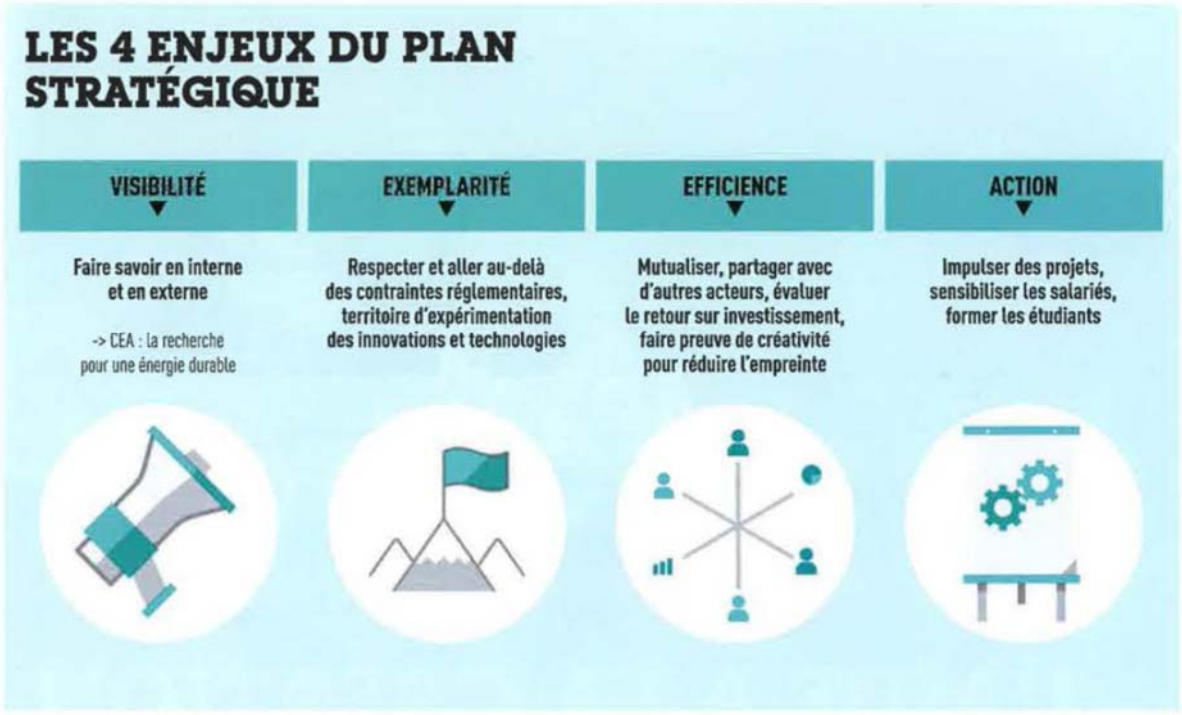
1. Creation of the position of Sustainable Development Executive Officer at CEA.
2. The position is directly attached to the Administrator General.

Best practices:

1. Recycling of all waste.
2. Measurement of rejections into the environment and air/water quality (CEA expertise in measurements of radioactivity, organization and procedures coming from nuclear activities).
3. Structures dedicated to technology transfer and industrial partnerships.

Current indicators

Indicators on the access of women to positions of scientific or managerial authority (topic included in RRI) and the recruitment of workers with disabilities (outside RRI framework) are included in the performance agreement with the State, and translated into the performance agreements between the General Division and operational divisions.



LES TROIS ENJEUX, PILIERS DU DÉVELOPPEMENT DURABLE

1

Environnement

Préserver, améliorer et valoriser l'environnement et les ressources naturelles sur le long terme, en maintenant les grands équilibres écologiques, en réduisant les risques et en prévenant les impacts environnementaux.
Le CEA, qui met en œuvre de nombreux procédés nucléaires, chimiques, biologiques, se préoccupe depuis longtemps de l'impact potentiel de ses activités ; en témoignent l'engagement des directions des centres en matière de management environnemental et le lancement d'actions de R&D sur la chimie verte, la dépollution des sols, l'économie de matière et le recyclage, à commencer par celui des combustibles nucléaires.

2

Social

Satisfaire les besoins humains et répondre à un objectif d'équité sociale.
Au CEA, cela passe par exemple par une politique d'achats responsables ou encore par la promotion de la mixité dans le cadre de l'accord sur l'égalité professionnelle signée entre les organisations syndicales et la direction générale du CEA… L'information et la concertation avec les parties prenantes sont depuis longtemps mises en œuvre autour des centres CEA au travers des Commissions locales d'information (CLI).

3

Économique

Développer la croissance et l'efficacité économique, au travers de modes de production et de consommation durables.
L'action du CEA vers l'industrie française (via des collaborations ou des transferts de technologies aux entreprises) et la valorisation des actions de R&D (créations de *start-up* ou dépôt de brevets) contribuent à un impact économique important du CEA : dynamisation du tissu industriel local, en particulier dans les territoires dans lesquels le CEA est implanté, et soutien à la croissance économique et à la création d'emploi pour le pays, en particulier dans les PME.

Figure 3. Sustainable Development at CEA (source: CEA Sustainable Development Executive Officer)

6. Reflection on review findings, Outlooks developed and ways forward

6. 1 The integrated or fragmented nature of different responsibility related dimensions

Like at the national level in France, CEA as an organization, its culture and structure, are better described by RRI keys than RRI dimensions. The keys, however, are seldom used together and an overall RRI vision is therefore fragmented. A more integrated vision would be welcome: the participants of the focus group meeting on February 15, 2018, asked that more such meetings would be organized among CEA staff working on different RRI keys.

6. 2 Common barriers and drivers

The main drivers of RRI keys at CEA are almost exclusively structural and often originate in regulatory measures. For example, ethics has become an important topic thanks to governmental action and new measures taken at the national level. However, the impact of recent high-profile breaches of scientific integrity has also been significant and clearly instrumental in speeding up change in CEA ethical policy. Similarly, CEA has been developing a large number of coordinated science education activities, mainly because science education is part of its official mission included in the performance agreement.

Structural factors are thus essential for RRI at CEA. However, there can be strong differences between the institutional dynamics of successful keys. For example, although science education is officially structured and coordinated across CEA, in reality many actions have been initiated and carried out bottom-up, through a multitude of local initiatives. This is in strong contrast with open access, for the use of the HAL database still depends on top-down impulse and mandatory measures coming from higher hierarchical levels. The difference between these two examples is primarily cultural: science education benefits from a large grass roots interest, while open access has so far failed to become a major issue among CEA scientists.

The restricted nature of some CEA research is a common barrier to several keys. It naturally limits the possibility of open access and public engagement. From the point of view of some actors, CEA research activities in the nuclear or military sectors are hardly compatible with ethical thinking. Such arguments add an extra layer of difficulty to adopting RRI. To solve these conundrums, CEA typically forms committees tasked with adapting national or European initiatives to its organizational reality. A good example of adaptation comes from the Gender key: after an internal deliberation, CEA established a gender indicator for its recruitment policy, in order to achieve the goals set by the government in the performance agreement. This measure is an original case of organizational appropriation of a policy common to all French research organizations.

Safety and security constraints also create an extra hurdle for science education and public engagement activities, for they result in restricted access to CEA centers. This common barrier

cannot be completely removed. As a result, many educational and public engagement activities take place outside CEA campuses.

6.3 Final reflections and plan for follow-up

This subsection has been transferred to the general conclusion.

7. Conclusions

7.1 Best practices scalable to European or national levels

The report lists best practices at the national level and, separately, within CEA. Here we recall several best practices among French research organizations. Relevant CEA best practices are listed in Chapter 5.

Gender: the *Mission pour la place des femmes* at CNRS, recently winning the *HR Excellence in Research* award, is an exemplary task force dedicated to gender equality. It could be a source of inspiration for research institutions throughout Europe.

CEA, which historically had a very high rate of male scientists, drastically changed its recruitment policy through the imposition a feminization rate of new hires superior by 5 points to the current staff feminization rate. This practice could be generalized to all scientific sectors with a low rate of female employees.

In France, as well as in many countries, traditional forms of public engagement have shown their limitations: attendance remains low; the sociological representativity of the audience (RRI dimension of inclusivity) is limited; meetings can easily be disrupted by small neo-Luddite groups. Online interactive formats are a possible alternative. However, our study has shown that Art & Science initiatives, e.g. EXPERIMENTA Biennale in Grenoble, are an effective and powerful tool to reach out to a larger audience and produce a deeper, long-lasting emotional engagement.

Training sessions for public outreach and ethical reflection should be a part of doctoral programs. Extra professional training on these subjects could also be beneficial for permanent staff. INRIA and Inserm are a model among French institutions but the entire country has a remarkable tradition of ethical reflection through dedicated committees and officers, which interact in a fruitful way with each other and with society. This is a scalable best practice.

CNES and CEA science education initiatives are remarkable by their scope and number. They show the importance of reaching out to every type of audience (primary, middle and high school students and teachers), through multiple media (school visits, lab visits, lectures, online tools, VR tools, etc.). Such activities rely on a network of researchers who are passionate about science education; their contribution should be supported accordingly by research institutions.

INRIA has efficiently promoted open access by evaluating researchers on the basis of publications deposited in HAL, the French national open access database for scientific publications.

7.2 Policy recommendations to national policy makers

In science education, the existence of official partnerships between research institutions and the Ministry of National Education is decisive for the creation of a stable institutional framework and obtaining trust of school teachers.

There exists a large variety of science education initiatives throughout the country, mostly carried out thanks to the passionate dedication of researchers. However, they remain essentially local. A national coordination of science education should be established in order to foster the comparison of best practices, provide a space for discussion, share documents and create an online national science education portal. This initiative should serve as a forum for a coordinated effort to promote up-to-date scientific content in high school programs. Research organizations should strive for a society in which citizens possess the knowledge necessary to understand the tools and devices that they use. This forum could also host a national discussion on public engagement initiatives.

The time and effort dedicated to science education should be included in the evaluation of participating researchers. Currently, few structural incentives exist; some parts of the scientific community even perceive educational activities as a distraction from mainstream research. This may lead to a 'loss' of work hours or possibly decreased competiveness of the research team. To change this attitude, science education should be considered as a regular part of the researcher's professional activity.

HAL, the national database for open access scientific publications, is a significant step forward towards open science. Efforts have to be pursued to bring different research institutions to a similar level of HAL use. HAL interface should be improved accordingly.

Public engagement does not have the same institutional weight at the national level as other RRI-related issues, e.g. gender or sustainable development. Public debates on scientific and technological issues are organized by CNDP, which does not possess specialized expertise on science. More anticipation and upstream work are necessary to inform the public and prepare fruitful debates. To maintain public trust, engagement activities should be transparent, including lucid and complete statements of conflict of interest.

In order to promote gender equality, strong symbolic measures, such as the nomination of women at top-level management positions, would send a strong message. Perception indicators should be used to analyze the evolution of perception and be a crucial part of any evidence-based policy on gender issues.

Ethics training should be developed at doctoral and master's levels. Since 2016, doctoral schools have an obligation to provide ethics training; however, specific methodological recommendations and constraints on the content of this training should be provided at the national level. National guidelines should strive to guarantee high-quality ethical training for all doctoral candidates.

France has a great tradition of ethics committees as well as of informal interaction between such committees. However, committees may sometimes produce a negative 'delegation effect':

researchers tend to consider that ethical reflection is the job of a dedicated committee, rather than pursuing deep thinking by themselves. Efforts should be made to avoid this effect. A "diffuse ethics" model promotes ethical reflection as a part of the researchers' practice, particularly during the conception of an innovative research project, even if this model requires a significant investment in time and resources. To this day, very little has been done on this subject at the national level.

In order to implement relevant indicators for research ethics, the activity of scientific integrity officers and operational ethics committees should be analyzed at the national level, possibly at the *Office Français de l'Intégrité Scientifique* (French Bureau for Scientific Integrity, OFIS[141]). Protected procedures to report integrity violation should be agreed upon. It is crucial that ethics indicators be used thoughtfully and without bias: one may expect that institutional progress will lead to a temporary increase of reported breaches, due to whistleblowers and a higher proportion of cases made public. In full awareness of this phenomenon, we recommend that the reputation of an institution be attached to its handling of ethical breaches, not to their mere existence. This is to avoid promoting a culture of silence among research organizations.

7.3 Policy recommendations to European policy makers

RRI thinking promotes many values which are already deeply rooted in the research community: science education, public engagement, ethical thinking, the researcher's responsibility in the creation of sustainable and desirable innovation. This explains why this project arose a considerable interest among French institutions: interviews, meetings and discussions have shown that there is a deep desire to learn more about the RRI approach, and how it can steer French research in the right direction.

The term "RRI" is seldom used in French policy documents; RRI keys are rarely mentioned together. The structure of research organizations and official discourse are typically not organized along RRI dimensions: they remain less visible and concrete than RRI keys. Essentially, a global RRI vision is promoted through the interaction with European agencies.

However, multiple activities are *de facto* organized along each of the RRI keys. Some of them exist in every organization, e.g. gender or ethics and integrity. In contrast, public engagement is more developed by NGOs than by public research institutions.

Historically, the structure of French research institutions has been adapted to the separate development of each key. Since the start of Horizon-2020, RRI has managed to introduce a change in this culture by pushing each organization individually toward a global, combined vision of RRI keys. The next step would include a national coordination of RRI initiatives. This is a slow-moving process due to the complexity of forces involved and to the resistance of existing institutional structures. However, a French RRI dynamics clearly exists and needs to be supported at the European level.

[141] http://www.hceres.fr/PRESENTATION/Organisation/Office-francais-de-l-integrite-scientifique

A unified RRI approach has met great institutional obstacles: a contextual, key-specific approach is still more effective and will yield better results. Since every French organization had shown particular strength on one or several RRI keys, what is needed is a complementary approach, by bringing together the experience of the entire French research community and sharing various best practices across institutions.

Open access key requires specific action at the European level. One of the main barriers to open science is the current business model of scientific publishers, which is unsustainable and constitutes a financial double penalty: research institutions pay for their publications twice, through journal subscriptions and through 'Gold' open access. This is clearly ineffective use of public funds. In order to promote Open Science, European institutions should work hand in hand with national institutions to put an end to this financial double penalty.

Our study showed that starting a discussion of researchers' responsibility can sometimes create an impression that scientists are being accused of irresponsibility. There is also a widespread anticipation that public engagement policies might lead to relativism and loss of research autonomy. It is thus highly important to insist that the European institutions maintain faith in scientific research and grant research autonomy to scientists. These are, and should be, core values of our institutions.

It is also important to stress the continuity and coherence between RRI and sustainable development. Promoting continuity is the best way to avoid simple "rebranding" or "RRI washing", which are also feared by the community.

RRI should not be taken by researchers as an additional burden beyond their existing research, teaching, and administrative duties. RRI should be presented as a framework that helps researchers carry out these tasks better and more efficiently, with regard to societal issues.

Research in Europe today is highly competitive. It is crucial that researchers, particularly young scientists, be rewarded for their effort in science education, ethical reflection, or public engagement. European Commission should consider positive measures to raise the value of such activities.

In order to become more than a rebranding, RRI should become a part of the institutional structure and also be incentivized at the individual level. Only then will RRI become real. European agencies are in good position to promote corresponding policy through global measures and targeted funding initiatives.

Annex: Resulting Matrices

Science education

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	Science education is part of the performance agreement.	Operating on several campus at national level, CEA employs thousands of engineers whose children attend school across the country.	Exchanges with Academies at a regional level.
RRI potential drivers	In each communication department of each center, in the most dynamic institutes and the Communication Department, there is an "educational actions" officer.	Researchers are highly motivated and heavily involved.	Concertation between research institutions and National Education authorities win teachers' trust.
RRI potential barriers	Time dedicated to science education is not taken into consideration in researchers' evaluation procedures.	CEA is sometimes perceived with distrust by actors from education and culture, who are rather a priori hostile to nuclear energy.	Evaluating the long term effects of an action is difficult, even if the feedback is very positive after meetings with researchers and lab visits.
Organization actions with the highest potential	Meetings with researchers, lab visits, initiation to scientific approach.		
Indicators of success	Number of researchers involved.	Number of students involved.	Impact on the CEA reputation.
Potential indicators of improvement	Number of involved teachers through the dissemination of methodological resources, human resources dedicated to science education, results from perception study within CEA staff.		

Ethics

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	Recent creation of an ethics committee.	Ethical thinking is not part of CEA culture, even if many researchers are involved in such thinking at an individual level.	Need to fill in "ethics" pages in call for projects, especially European ones.
RRI potential drivers	Evolution of regulatory framework in ethics and scientific integrity.	Scientific integrity training for doctoral students.	European demands in ethics analysis and review for projects funded by the European commission create an incentive to create adequate structures.
RRI potential barriers	Difficulties to strengthen the authority of the ethics committee in a management structure geared towards the targets of the performance agreement.	Perceived incompatibility between ethics and some CEA research fields, especially in nuclear energy and national defense.	Lack of experience and training among researchers on the formal treatment of ethical issues.
Organization actions with the highest potential	Recent creation of the ethics committee	Participation of CEA to the CERNA ethics commission and the dissemination of its reports.	Development of ethical researches at LARSIM.
Indicators of success	Absolute number and percentage of reported breaches, percentage of external members in ethics committees, results of perception study on ethics actions within CEA staff (perception of encouragement to ethical behavior within the institution, awareness of existing institutions and procedures).		

Public engagement

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	Communication units within the CEA centers are in charge of organizing public debates.	CEA employees are located in several municipalities close to CEA centers.	Access to CEA sites is made difficult by security constraints.
RRI potential drivers	The organization of public debates is demanded by law or by public authorities.	Many CEA employees are passionate about technological development.	Progressive realization by the institution and CEA employees of the need to develop a serene science-society dialog.
RRI potential barriers	The training level of CEA employees to contradictory public debates remains weak.	CEA research topics are often passionately debated. Public debates are often usurped by small groups.	The instruments of public debates provided by law do not allow for a large rational debate on technological issues.
Organization actions with the highest potential	Organization of the interaction with CLIs.		Organization of conferences and training sessions in every CEA center during the CNDP national debate on nanotechnologies.
Indicators of success	Total budget allocated to the activity, number of hours dedicated to it by CEA employees and invited artists, numbers of the audience attending public meetings, media impact studies on news outlets (number of pages and webpages, readership measures)	Evolution of the CEA public image	

Gender

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	Signature of agreements on professional equality	Raising awareness among CEA employees	Perception study on CEA agents
RRI potential drivers	CEA committed to numeric targets.	Fast and global evolution of mentalities on those issues in the entire society.	Younger generations pay more attention to those issues than the preceding ones.
RRI potential barriers	Lack of parity in CEA executive instances.	Cultural effects induced by the very masculine recruitment of the institution at its beginning.	
Organization actions with the highest potential	Increase in the proportion of women in permanent positions through an annual feminization recruitment rate 5 points above the permanent staff rate.		Organization of an internal perception study on gender issues.
Indicators of success	Dedicated indicators and monitoring at the recruitment level (current feminization rate, feminization rate among new recruits)	Use of perception indicators	
Potential indicators of improvement	Use of perception indicators as a complement to numeric indicators relative to recruitment policy (number of women in positions of strong operational responsibility, financial and human resources dedicated to gender equality).		

Open access

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	HAL membership	Publication practices vary a lot from one scientific domain to another.	
RRI potential drivers	Obligation of publishing in open access imposed by some research funding agencies	Growth of the open access culture in the scientific community.	

Obstacles potentiels à la RRI	Absence of verification of open access publications in the researchers' yearly evaluation. Restrictive nature of some studies. Prohibitive cost of some subscriptions and accesses.	Absence of incentives for CEA researchers to systematically deposit their publications on HAL.	
Organization actions with the highest potential	Creation of HAL-CEA	Distribution of brochures by the Documentation divisions.	Inclusion of open access in the ethics and scientific integrity sensitivity training.
Indicators of success	Percentage of publications in open access among non-confidential papers, percentage by laboratory and by researcher, financial and human resources dedicated to open access, awareness of open access in internal studies		Numbers of publications in HAL-CEA.

Anticipation and reflexivity

	Structural	Cultural	Related to interchange dynamics
Organizational aspects	Multiple units involved in anticipation (DAS, DRT, DPg, HC)	Open environment gathering innovation providers and users (Open Lab, Factory Lab)	Support to start-up creation and innovation in the French industry
RRI potential drivers	Incentives towards innovation from new uses, especially in the digital world.	CEA missions on great cross-sectional issues of the energy strategy and digital transition.	CEA participation to the elaboration of national roadmaps and scenarios.
RRI potential barriers	Topical compartmentalization of studies.	Tension between technopush and market-pull approaches.	
Organization actions with the highest potential	Existence of a *Service Marketing stratégique* dedicated to innovation marketing.	Partnerships with large corporations.	

Indicators of success	Indicators on key partnerships (duration, size,…) and number of jobs created.		

Sustainable Development

	Structural issues	Cultural issues	Related to interchange dynamics
Organizational aspects	Signature of the chart for sustainable development for public institutions and corporations.		
RRI potential drivers	Nomination of the Sustainable Development Executive Officer at CEA, attached to the general administration.	Social and governmental demands.	
RRI potential barriers	No dedicated budget, weak human resources.	Weak knowledge of corporate social responsibility and sustainable development by CEA.	Weak concertation between CEA centers.
Organization actions with the highest potential	Recycling of waste, nuclear safety, geological storage, research in sustainable energies.		Participation to the conception of the national energy strategy.
Indicators of success	Gender and disability indicators.		